A MANUAL

OF

FRACTURES AND DISLOCATIONS

BY

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TO

"UNCLE BILL"

Whose title denotes the affectionate respect of his Staff

PREFACE

This handbook is intended primarily for medical students but it is hoped that general practitioners will find it of value. It is designed as a guide to the wealth of material that is published in text-books and articles which bewilder the student with their mass of detail. No attempt has been made to make the book an exhaustive treatise; the student is referred to the standard texts for elaboration. Although fracture surgery is becoming a specialty, nevertheless every doctor, be he psychiatrist or obstetrician, will sooner or later encounter a fracture, possibly in his own household. The author hopes that this volume will give him the fundamental knowledge he may need without burdening him with the detailed information demanded of the expert.

Grateful acknowledgment is made of the unlimited time and assistance given by the members of the Staff of the Fracture Service of the Presbyterian Hospital, New York City. The author wishes particularly to express her gratitude to the illustrators, Anna K. Stimson and Martha G. Hunter, who with tireless patience and skill have labored to express in black and white her nebulous ideas. Without the painstaking secretarial aid of Jessie A. Harding this book might not have been written.

B. B. S.

New York City

FOREWORD

The Staff of the Fracture Service at the Columbia Presbyterian Medical Center has felt the need of a brief outline of the diagnosis and treatment of fractures Doctor Stimson has been an active member of this Staff since its beginning ten years ago It is hoped that this book will prove as valuable to students and practitioners elsewhere as we expect it will be to us The book has the hearty approval of Dr Clay Ray Murray and myself

William Darrach M.D

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FRACTURES AND DISLOCATIONS

PART I

GENERAL CONSIDERATIONS

CHAPTER I

DEFINITION, CLASSIFICATION AND DIAGNOSIS OF FRACTURES.

DEFINITION OF FRACTURES

UNDER the scrutiny of compensation boards insurance companies and civil courts fractures are no longer considered necessary though uninteresting evils but important and challenging problems Once merely a broken bone to be put together and held until it stuck like a broken chair leg a fracture is now "an injury to an individual involving a portion of the body in which there exists a solution of continuity of bone and the results of its treatment are measured in terms of economics sociology and psychology as well as anatomy

A fracture is an injury It is not a disease with a slow onset nor is it a surgical operation of choice allowing preparation of mind and affairs It is an emergency that usually occurs to individuals who in the midst of health are pursuing their occupations or pleasures. It comes without warning and therefore is associated with some degree of mental shock. Because it is an injury it is accompanied by trauma to other structures. A broken bone is not an isolated phe-

nomenon there are torn vessels, bruised muscles lacerated periosteum contused nerves sometimes there are injured internal organs sometimes lacerated skin This soft part damage is always present and must be taken into consideration

A fracture occurs in an individual. Frequently overlooked this fact is of the utmost importance for age sex and mode of living all influence the treatment and outcome of the case Child adult, or octogenarian each presents his own problems A slight deformity resulting from a broken clavicle may be unsightly with an evening dress but of no importance under a man s shirt. The patient s occupation must be considered Is he a laborer or a pianist a clerk or a watchmaker? Will he lose his job if he comes into the hospital for a few days or can he cut coupons just as well in a private room as he can in the office? The temperament of the patient must be recognized for it is necessary to know if he will carry out instructions intelligently if he can be jollied or if he must be bullied into obeying orders. So much of the functional result in fractures depends on the patient that his coöperation must be gained from the outset. In surgical cases a cholecystectomy for example with adequate surgical and nursing care the intestinal tract functions regardless of the patient. But in a fracture case the usefulness of the extremity depends on the patient himself no matter how satisfactory the late *x*-ray pictures may be

Two cases may serve to illustrate the foregoing Two women slipped and fell on an icy sidewalk landing on their outstretched right hands. Both sustained fractures of the lower end of the right radius Colles fractures. Both went to the same doctor and the examination and *x* ray pictures of each were strikingly similar They received the same treatment of immediate reduction and immobilization with splints for the same period of time One woman was the wife of a laborer with five children to look after and all the help

she had was that which the neighbors gave her From the first day she was moving her fingers and trying to help herself She was sensible rather stoical, and, having complete confidence in her doctor, she obeyed instructions when the splints were removed and used her hand and wrist. She had an excellent functional as well as anatomical result in a minimal space of time The other woman was a society matron whose heaviest occupation was holding cards at bridge. She had a personal maid and refused to help herself in any way When the splints were removed the fingers were swollen stiff, and painful on attempted motion Having heard that one of her friends had "electric treatments' for a similar injury she demanded them but as she expected the treatments to do all the work she could not understand why her wrist and hand remained sore and stiff for weeks. The anatomical result was as good in the second case as it was in the first The fractures were the same but the individuals were different

A fracture involves a portion of the body Different parts of the body have dissimilar functions and must be treated accordingly The upper extremity has a wide range of motion and is capable of performing skilled and fine acts, mobility therefore must be preserved The function of the lower extremity is static and progressive weight-bearing *i e* standing and walking axis length and stability are essential In a fracture of a phalanx of the finger every effort is directed toward retaining the motion of the finger if possible. A stiff finger joint may be a serious economic handicap A broken phalanx of a toe on the contrary is treated in such a way as to prevent a deformity which might give pain on weight bearing, limited motion in a toe-joint is of relatively little importance.

Finally a fracture is a break in a bone The kind of bone involved the location of the injury in the bone, and the character of the break are factors which must be taken into consideration in an intelligent choice of treatment.

CLASSIFICATION OF FRACTURES

Fractures are divided into two main groups, simple and compound A fracture is called simple when there is no wound of the skin communicating with the break in the bone. A fracture is compound when the break in the bone communicates with the outside air through a wound in the skin and is therefore potentially infected

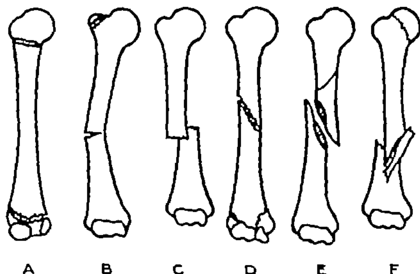


Fig. 1 —Types of fractures.

A fracture may be a bend or a buckling in the bone it may appear as a crack a fissure or a depression it may be complete with the broken bone ends transverse oblique or spiral It may consist of a small chip avulsed from the main bone or it may be comminuted *i e* consist of three or more fragments (Fig 1)

Various kinds of displacements may occur One fragment can be tilted on the other causing an angulation in the contour of the bone If the fracture is complete one fragment can shift on the other anteriorly posteriorly laterally or medially It can also rotate. The lower fragment can

be pushed upward or cephalad becoming impacted if it is still in contact with the other fragment, or overriding it if it has moved the full width of the bone It can be forced downward or caudad by massive swelling and hemorrhage or by overpull Customarily the smaller fragment is said to be displaced on the larger or the distal on the proximal one

DIAGNOSIS OF FRACTURES

The history of a fracture patient is usually so simple and straightforward that it is frequently very carelessly taken The man slipped and fell and hurt his arm " is unfortunately often seen on charts. Definite information must be obtained and certain questions asked The time of the accident is important Was it within an hour or was it a week ago? The place of the fall must be recorded and a special note made if the patient was working because of the compensation laws. What was he doing at the time of injury? Walking, running skating etc ? How did he land? That is always a difficult question for a patient to answer, for a fall comes so unexpectedly that he finds himself suddenly on the ground and is rarely quite sure in what order he arrived there too much credence should not be given to his story What happened next? This is of great interest and must be carefully investigated Did he notice that his arm hurt at once or that he could not use it or that it looked crooked? If there was deformity it is important to know if a friend or bystander pulled on the arm and made it look better *i e* reduced a dislocation Has he noticed any tingling numbness or lack of motion of his fingers *i e* is there a suggestion of nerve lesion? Has he tried any home remedies before coming to the doctor? It is valuable to know that the redness and blisters on the skin are due to overenthusiastic applications of iodine Has he ever hurt that arm before? Frequently an old deformity will complicate the diagnosis of a fresh fracture if its existence is not suspected

An elaborate and lengthy history is not necessary but all the salient facts both negative and positive must be written down both for the better treatment of the patient and for the sake of the doctor Many of these cases are medicolegal and inadequate and inaccurate histories may prove embarrassing to the doctor on the witness stand or to subsequent doctors treating the case

The examination of the patient must begin with a consideration of the individual Is he in pain? Is he in shock? Sometimes only a cursory examination is possible before supportive measures are instituted in order to save life. This seems self-evident, but it is surprising how often the attention of students and internes is taken up with some obvious deformity to the neglect of the general condition of the patient. If he is not unconscious nor in shock it is important to make a quick estimate of the characteristics of the individual Is he stoical or neurotic frightened or in pain? The interpretation of the local examination must be based on this estimate to be of any real value

The local examination must above all things be gentle. It need be no less painstaking and careful but if the coöperation of the patient is lost at the beginning it may never be completely regained This is particularly true with children. Also damage can be done to soft parts and splintered bone ends by rough and thoughtless handling Inspection will tell a great deal if the eyes are trained and know for what to look. Comparison of the two extremities should always be *made for failure to do so may cause a normal* individual variation to be considered the result of a recent injury Deformity or change in the contour due to change in the bony framework must be sought, and any deviation from the normal anatomical landmarks recognized and interpreted Soft part swelling is frequently present and may mask slight deformity Ecchymosis is the discoloration of skin caused by the underlying extravasation of blood and is suggestive of the existence of a fracture, especially if it is seen two or three days after the injury It frequently

appears at some distance from the site of the break in the bone because the blood from the bone ends passes down the fascial planes gradually approaching the surface Ecchymosis is seen sooner and nearer the fracture if there has been extensive tearing of the soft parts. It is important to notice how much the patient is able to move the injured extremity In early cases with obvious deformity care must be taken to prevent the patient from injuring himself further by ill-advised motions.

Palpation should begin well away from the obviously painful area. Occasionally the inexperienced doctor pounces on the sore spot with eager fingers the patient naturally jerks away and it is with considerable difficulty that the examination proceeds. Confidence must be gained by gentle handling and all painful procedures should be postponed as long as possible. Where no visible deformity has been seen, direct bony tenderness should be carefully mapped out. This can frequently be done by the patient himself if he is given a pencil and shown how to press the eraser end along the shaft of the bone until he finds the point or line that hurts the most. With care the line of the fracture can be traced on the skin. Indirect or transmitted tenderness is a sign of importance to distinguish a break from a soft part lesion It is elicited by gentle pressure on the extremities of a bone in the axis of its shaft Bony irregularity can be felt even when masked by swelling Bony crepitus and a false point of motion are definite evidences of the existence of a fracture but should never be elicited unless absolutely necessary to establish the diagnosis To do so may cause extensive damage to soft parts and bone ends

The condition of the circulation as manifested by the temperature and color of the extremity and the presence or absence of adjacent pulses should always be included in the initial examination A rapid investigation of the sensory and motor functions will demonstrate the condition of the peripheral nerves and should not be omitted for it is essential to know the extent of the damage as soon as possible Ves-

sels and nerves are occasionally injured during the course of treatment and a note of the presence or absence of circulatory or neurological lesions existing before treatment is started may save both the patient and doctor from later difficulties.

The existence of other injuries must never be overlooked It is possible to have two or more fractures in the same individual and it is embarrassing to find the second fracture some days or weeks after the first. The attention should not be so concentrated on the obvious that the less conspicuous is missed

The history and examination of the man who fell and hurt his arm may serve to illustrate the preceding paragraphs. A twenty five-year-old man enters the clinic complaining of pain in his left elbow of about four hours duration He states that while playing football he slipped and fell landing with his arm under him. When he sat up his elbow looked crooked and though there was not much pain he found he could not use the arm His fellow-players pulled on his hand and something seemed to slip into place As there was immediate improvement of function the patient believed he was not seriously hurt and went home. The pain steadily increased however and the swelling became so marked that he decided to seek professional help At no time has he noticed numbness or tingling in his fingers and he has been able to move them since the accident. There has been no previous injury to the arm and his general health has always been excellent. His job is that of a clerk in a drygoods store and he is certain it will be kept for him

The examination shows a well-built young man in obvious pain but no apparent shock. His color is good and he is laughing and joking with his companions though he protects and supports his left elbow with his other hand He removes his coat and shirt with considerable difficulty Though there is marked swelling around the left elbow the axes of arm and forearm are similar to those of the opposite side and there is no visible deformity The color of the skin is normal

Motions at the elbow are possible but are limited in extent Flexion and extension of the forearm on the arm are about one-half the range of similar motions in the uninjured extremity and pronation and supination of the forearm about one-quarter Wrist and finger motions are complete and painless On gentle palpation it is found that the bony landmarks of the elbow joint are in their normal positions There is generalized tenderness around the entire elbow but sharply localized tenderness over the radial head Pressure on the radial head makes voluntary pronation and supination almost impossible because of pain. Longitudinal compression of the forearm causes pain in the region of the radial head The radial pulse is palpable and equal in strength to that on the uninjured side No sensory changes are made out. There is no evidence of any other injury

The tentative diagnosis is a reduced dislocation of the left elbow associated with a probable fracture of the radial head *X*-ray examination is necessary for confirmation of the diagnosis.

At this point it may be asked why it is necessary to bother with careful history and physical examination when *x* ray pictures will show the fracture more accurately than any other means. Unfortunately the tendency at the present time is to depend almost entirely upon the *x*-ray findings, with the result that clinical observations are becoming almost negligible Doctors forget that *x* ray machines are not always available. It is a poorly trained practitioner who has to wait for a roentgenologist to tell him some twenty four hours later that he has done an adequate reduction If he knows the normal anatomy he should be able to tell at the time of the reduction whether or not he has been able to regain it. Of course the *x* ray is of inestimable value but it should be used to support, not to supplant clinical observation and judgment As has been said before many fractures are compensation cases accident cases etc and therefore medicolegal and it should not be forgotten that *x* ray films form an important part of the evidence

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period of from twenty minutes to one-half hour during which time the nerve endings are insensitive, a period of tissue shock. During this time the muscles surrounding the fracture are relatively flaccid After the immediate tissue shock has subsided sensation returns and the muscles go into protective spasm

Repair of a fracture begins almost as soon as injury occurs It is influenced by many factors but its underlying principles remain the same First the blood clots, and a fibrin network is formed in the clot. Fibroblasts grow in from the surrounding connective tissue. Blood vessels bud into the mass and granulation tissue forms As the circulation improves the products of tissue death are removed There is an absorption of calcium from the broken bone ends with a concentration of calcium in the tissues immediately surrounding the fracture site Electrochemical examination at this time shows the tissue fluids to be of a slightly acid character As the process continues the calcium held in the vicinity is deposited in the granulation tissue in rough, irregular trabeculæ thus forming callus With the improvement of the circulation both blood and lymphatic the acidity diminishes and the reaction of the tissue fluids becomes slightly alkaline With resorption and further deposition the trabeculæ become more dense and eventually new cortical bone is formed Whether the deposition of calcium is due to the action of an osteogenetic cell to enzyme action or to a physico-chemical phenomenon is not a matter for discussion here Conditions apparently needed for bone healing after fracture are hemorrhage tissue death calcium concentration in the immediate neighborhood granulation tissue, and adequate circulation

Modification of the process of bone repair may be brought about by various factors. The first is the extent of injury If the damage to the bone is very slight as in a crack or buckling the hemorrhage will be negligible and the resultant granulation tissue minimal If on the other hand the fracture is complete with displacement of the fragments the

CHAPTER II

BONE REPAIR IN FRACTURES

In order that the signs and symptoms presented by a fracture may be interpreted, and that the treatment may be based on a rational foundation it is necessary to have some understanding not only of the processes which occur at the time of injury and during the period of repair but also of the factors which influence these processes

What happens when a bone breaks? Every fractured bone bleeds, no matter how small it is or where situated The amount of extravasated blood depends upon the number and size of blood vessels ruptured. In a green-stick fracture, for instance, the bleeding is minimal. On the other hand a break in the shaft of a long bone with several fragments and considerable displacement may be surrounded by a large mass of blood With the injury to the bone there is also damage to the surrounding soft parts This may consist of the death of a few cells or may mean extensive tearing of fascia, muscle subcutaneous tissue and even skin. Nerves and large blood vessels may be involved in the damage These phenomena occur at the time of the accident and may continue for a period of minutes or hours, depending on the extent of the initial injury and on the secondary trauma which will be discussed later The extravasated blood from the broken bone and the torn soft parts acts as an irritant as does the dead and damaged tissue. Following injury therefore there is locally a flow of tissue fluids to the fracture site with an infiltration of wandering cells. This process begins within a few minutes of the accident and may extend over days Systemically this local inflammation manifests itself in a rise in temperature and an increased white cell count. All these changes i. e extravasation of blood tissue death edema local inflammation vary in extent directly in proportion to the amount of the initial trauma.

Immediately following the accident there is usually a

be considered in discussing the influence of the fracture site on bone repair The irregular trabeculæ of cancellous bone form more rapidly than the dense structure of cortical bone because of the need for greater adaptation in the latter, but their formation is more easily subject to change under stress than is the denser structure

Of the systemic factors which influence bone healing age plays a part only in the difference of healing between a child and an adult. After adolescence age *per se* seems to have no marked influence Systemic diseases, endocrine disturbances conditions of the skeleton itself, have little influence on the local repair processes.

The factors so far discussed are uncontrollable so far as the doctor is concerned Certain factors however are definitely within his power to control The first of these is secondary trauma. By this is meant the damage to the bone and to the surrounding tissues which follows the original injury and which is caused by careless transportation rough examination and lack of adequate immediate splinting The more extensive the soft part damage and the greater the circulatory embarrassment so much the slower will be the repair process. Interposition of soft parts, *viz.* periosteum or muscle between the bone ends serves as a barrier to the formation of callus and in many cases will prevent bony union unless removed Impaired circulation due not only to direct damage of the vessels but to edema prolonged by dependency of the extremity or by constricting bandages and splints undoubtedly delays the restoration of normal conditions not only of the bone but also of the soft parts. Adequate circulation not only of blood but of lymph is essential for the removal of the products of tissue death and for the nourishment of the repair tissue Motion at the fracture site of the shaft of a long bone during the healing process will cause the formation of fibrous tissue and inadequate bone repair On the other hand immobilization of a fracture into a joint may lead to the formation of fibrous tissue bands from the site of the break to the capsule

hemorrhage may be so great that the fluid is an actual block to repair and the formation of the granulation tissue much delayed A fracture that is comminuted presents a different problem from one that is in only two pieces because of the extent of bone surface present with a possible increase in the available calcium The extent of damage to the soft parts also plays a rôle in the repair of the bone. Stripping of the periosteum from the underlying bone tears the communicating vessels with resultant damage to the circulation of the bone. Injury to large vessels may interfere with the circulatory status of the part not only because of the tearing and thrombosis of the vessels themselves but also secondarily because of the pressure caused by the stagnation of the fluids Injury to the muscles with massive tearing will increase the extravasation of blood and the death of tissue which together will result in increased local inflammation with edema extensive granulation tissue and later fibrosis If the skin is injured the problem of contamination and possible infection is introduced

The second factor of great importance is the site of injury A fracture through an area of bone which is surrounded by soft parts muscle attachments, etc. and has a good circulation usually heals with a large amount of callus A fracture where there are few if any soft part attachments and limited circulation will heal slowly if at all. For example fractures of the neck of the femur and fractures of the carpal navicular are noted for their poor healing powers. Fractures in the intertrochanteric region heal with abundant callus. A fracture into a joint will bleed into the joint but if there is little soft part damage the blood will not clot. Healing then must occur across the fracture line in the minimal granulation tissue formed from the cells of the bone itself and not through enveloping callus. A fracture through an epiphysis presents the possibility of interference with growth because the injury may cause a premature ossification of the epiphyseal cartilage

The type of bone i e cancellous or cortical must also

and is apparently not painful Careful examination and x-ray plates in two planes will frequently reveal in these cases a green-stick fracture of the tibia

A broken bone presents certain signs as evidence of its existence. Each is not invariably present in every fracture and some are present when no fracture exists *Swelling* though present in many other conditions, is one of the most constant signs of a fracture. When it occurs immediately after injury it is due to the bleeding from the bone and soft parts. It presents a circumscribed sharply outlined appearance in contradistinction to the later indistinctly outlined swelling caused by the edematous infiltration *Deformity* is a deviation from the normal anatomical structure. It is caused by displacement of the bony framework, as in a fracture or dislocation but may also be caused by changes in configuration due to such conditions as neoplasm tuberculosis etc Changes in shape in length in axis in alignment and in rotation are all types of deformity and are caused by structural changes in bone or joint, most frequently by fracture or dislocation.

Ecchymosis the discoloration of the skin due to the extravasation of blood is very suggestive of a fracture when it appears at some distance from the painful area several days after injury Ecchymosis which is visible immediately after the accident may be due to soft part injury alone or to such extensive tearing of tissue that the blood from the deep structures finds its way to the surface at once instead of draining along fascial planes For example ecchymosis seen in the front of an elbow immediately after a patient has received a severe fracture of the radial head indicates a torn joint capsule lacerated brachialis fibers and damaged fascia which have allowed the blood from the broken bone to manifest itself under the skin In a less severe injury the blood from the fractured radial head is held within the joint by the intact capsule as is evidenced by the clinical appearance of a hemarthrosis.

CHAPTER III

SYMPTOMS AND SIGNS OF FRACTURES

BEFORE discussing the principles of treatment let us attempt to translate the pathological and physiological changes described in the preceding chapter into terms of clinical significance. When a patient receives a fracture he is aware of two symptoms each of which is always present though in varying degree. The first is *pain* This usually is instantaneous but may then disappear completely during the period of local tissue shock, leaving the patient aware only of a feeling of numbness As the latent period passes off pain may recur to be sharply accentuated on every movement of the injured limb Each motion of the unsplinted extremity drives the broken jagged bone ends into the surrounding tissues causing more bleeding more swelling more pressure and more pain The muscles of the limb contract spasmodically and as the muscles go into protective spasm with further shifting of the fragments the pain is increased but can be relieved by the application of traction and firm splinting which will relax the spasm and tend to prevent motion at the fracture site. When there has been little displacement of the bones and when the fracture is incomplete the symptom of pain is much less prominent. Another manifestation of injury is that of *impairment of function* The patient is aware that something is not right with the extremity and is conscious of the fact that he cannot use it. This occurs even in cases where pain is not an outstanding characteristic Frequently a patient will say that he "just knew there was something wrong with his arm though he cannot explain why he felt that way This is particularly true in children who after a fall will refuse to walk on a leg which shows no gross evidence of fracture

As has been said before all these signs do not always occur in all fractures. Combinations of them are always present For example, in the instance of a man with a reduced dislocation at the elbow and an undisplaced fracture of the radial head pain and impaired function are present so both symptoms are observed There is no gross deformity no ecchymosis, but there is swelling and definite limitation of motion at the elbow Palpation reveals tenderness over the head of the radius, and pressure on the forearm from wrist and elbow produces indirect tenderness at the same place. Crepitus and false point of motion are not present. Nevertheless the positive signs *i. e*, swelling limitation of motion, direct and indirect tenderness are sufficiently suggestive to warrant the diagnosis of fracture A second case, that of an individual who has broken the shaft of a long bone presents practically all the signs and symptoms described Pain and loss of function are evident. There is gross deformity *i e* shortening of the leg and change in the axis of the bone Ecchymosis is not visible though it will be present in a few days There is indirect tenderness complete loss of motion of the extremity because of the lack of continuity of the shaft there is a false point of motion easily visible and palpable Crepitus in this case should be gently elicited because its absence is indicative of the interposition of soft parts which will not allow the bone ends to rub on each other

The signs and symptoms so far discussed are all those of a fresh fracture As time elapses the signs change in accordance with the changes going on within the extremity At five days for example there will be less pain but still some impairment of function depending upon the site of injury If the deformity has not been corrected it will still be present, there will be considerable edematous swelling around the area. Ecchymosis in the dependent portion of the extremity will be visible It will be less easy to palpate the bony irregularity because of the organizing hematoma around the bone ends The range of motion will still be limited Ten

Abnormal mobility can be manifested in three ways—the range of motion can be limited the arc of motion can be altered, or there can be a false point of motion For example, if an elbow can normally move from 30 to 185 degrees and after injury can move only from 80 to 130 degrees, there is definite limitation of motion If however it can move from 50 to 205 degrees the range of motion (155 degrees) is the same but the arc is different.

The signs so far described can all be seen. Other evidences of fracture can be elicited by palpation. The first of these is *direct tenderness* This, however can be misleading if there is a contusion or an abrasion at the fracture site for the tenderness may be due to the soft part damage caused by the blow A more accurate sign of fracture is *indirect tenderness* which is produced by pressure in the long axis of the bone exerted at its two extremities If there is a break in the continuity of the shaft such pressure will cause pain at the fracture site which is quite distinct from the pain of the injured soft parts. *Bony irregularity* can occasionally be felt when there is no visible deformity The smooth contour of the cortex may be interrupted by a ridge or shelf of broken bone.

Two signs of fracture which are considered pathognomonic when they are present are *crepitus* and *false point of motion*. A word of warning should be inserted here that these two signs should not be elicited unless absolutely necessary because of the danger of causing further damage to the bone fragments and to the surrounding soft parts. Bony crepitus is the gritting sensation transmitted to the palpating fingers by the contact of the broken bone ends on each other There are other forms of crepitus that felt in certain types of tenosynovitis in organizing hematomas, in cases of villous synovitis but bony crepitus once felt is unmistakable A false point of motion is that which occurs when there is a complete fracture of the shaft of a long bone when there is obvious motion where no motion should be.

CHAPTER IV

PRINCIPLES OF TREATMENT OF FRACTURES

EMERGENCY TREATMENT OF FRACTURES

"SPLINT 'em where they lie" is so familiar a slogan that the reasons behind it may be forgotten. Protection against the secondary trauma of kindly but clumsy handling, ill-planned transportation, and overzealous examination may materially shorten the healing period. This secondary damage may be more extensive than that caused by the original injury.

A sixteen-year-old boy while playing sand lot football was tackled and thrown in such a way that as he fell his leg was doubled over a stone. He felt immediate pain in his right thigh. His playmates lifted him to his feet but the leg crumpled under him and he fell again. He was dragged to the side of the field where it was some time before a passing motorist took him to his home. He was carried up three flights of stairs with the injured leg dangling and twisting in the arms of his bearers. A doctor was called who applied a wooden splint from hip barely to knee and ordered x-ray pictures. The family was so poor that a portable x-ray machine was not available and the boy was carried down the three flights of stairs to the doctor's office where the x-ray films were made, then back up the stairs again. Twenty four hours later the family was told that the boy had a broken femur and should be in the hospital. He was carried down the three flights of stairs again and taken in the back seat of a cab to the hospital. X ray examination showed a long spiral fracture of the femur with nearly 3 inches overriding, both ends of the broken bone having pierced the surrounding muscles. An operation was necessary because of the damage to the soft parts and the interposition of the muscle

derness will be present but less sharply defined and indirect tenderness will also be present. There may still be abnormal mobility of the shaft but it will be less free because of the newly forming granulation tissue

At five weeks the signs will have changed considerably There will be no pain under ordinary circumstances and the limitation of function will be diminishing The deformity will of course, remain if it has not been corrected The out line will be rounded, however by the underlying callus There will be no ecchymosis, for the discoloration will usually have disappeared by this time The range of motion will have increased but probably will not have returned to normal. Tenderness and indirect tenderness will probably both be absent. Crepitus cannot be elicited and the only evidence of false point of motion will be a springy or an elastic sensation at the fracture site because the callus will be sufficiently formed to prevent motion of the bone ends The callus may be palpable as a cylindrical or fusiform mass of tissue which feels dense and elastic.

tures before the muscles go into spasm If traction can be applied during this period the length of the extremity may be maintained and overriding due to the pull of the muscles prevented If the broken ends of the bone are allowed to move the jagged ends may tear the surrounding fascia muscles, and possibly nerves and blood vessels It is conceivable that a spike of bone may penetrate the skin converting a simple fracture into one that is compound

So far nothing has been said about the effect of an unsplinted fracture on the general condition of the patient Each move causes pain with its accompaniment of apprehension and fear, increases the shock, mental as well as physical and so delays the return to normal Treatment of the fracture should begin at the time of injury

PERMANENT TREATMENT OF FRACTURES

After the patient has been brought to the hospital or to the doctor s office and the history physical examination and x-ray pictures have been completed the decision must be made as to the form of treatment best suited to the case. This choice does not depend primarily on the fracture First an evaluation of the patient must be made Is he dependable and coöperative? Can he be counted on to obey instructions or must some form of treatment be used which will protect him from himself? Is he economically independent? In other words can he come to the hospital for needed care or must every effort be made to allow him to continue work while his fracture heals? What kind of work does he do? What is his general condition? Has he some respiratory or cardiac disease which will increase the danger of an anesthetic? Is he so old that it will be dangerous to keep him in bed? All these points must be kept in mind in the evaluation of the patient before definitive treatment is decided upon There are times when the best treatment for the patient is not the best for the broken bone

Contrast this case with that of a slightly older boy who hurt his leg in an intercollegiate football game He was allowed to lie where he fell on the field until the college physician could apply a Thomas splint. He was then taken from the field to the hospital His x ray films showed a complete fracture of the bone but in perfect anatomical position. There was little injury to the soft parts The difference in healing time between those two cases was marked

It seems to be instinctive for any layman witnessing an accident to lift the patient to a standing position and unfortunately it is usually a layman and not a doctor who is first on the scene of the accident. Therefore widespread public education is being carried on by the Fracture Committee of the American College of Surgeons Boy Scouts firemen and police are being instructed in the application of splints.

The Thomas splint for fractures of the leg is the most efficient apparatus devised for temporary splinting and transportation. A similar splint is made for fractures of the upper extremity If these are not available, however, other means can be utilized for applying and maintaining traction in the long axis of the extremity and for holding the part immobilized until permanent treatment can be instituted If there is no other way the leg can be pulled by doctor or layman against countertraction with the pull maintained until the hospital is reached

During the construction of a large bridge one of the workmen fell a distance of about 15 feet, landing with one leg twisted under him the leg lying at right angles to the thigh The foreman ran to him and while another workman held the patient s shoulders, pulled on the leg straightening it and maintaining constant pull while the man was rushed to the hospital by car By the time he had reached the hospital the foreman had made an accurate reduction of the fracture.

Why should this be true? As we have seen in the preceding chapter there is a latent period in practically all frac

its normal position This cannot be emphasized too strongly as each fracture is an individual problem and should be treated as such

The splints which are applied after the reduction should be long enough to immobilize the fracture site adequately and yet not so long as to impede the motion of such joints as can be safely moved If the patient is to be restored to activity as soon as possible it is important for him to maintain the function of the extremity insofar as it is consistent with the repair of the bone For example in a fracture of the wrist it is not only unnecessary but unwise to bring the splints down to the finger-tips. The motion of the fingers in such cases is essential for the maintenance of the usefulness of the extremity

Treatment by closed reduction and immobilization is satisfactory in many fractures. It is, however of questionable use in those oblique fractures that tend to slip because of the muscle pull and the configuration of the bone ends. In such cases some form of continuous traction must be used

Traction and Suspension.—Traction of various types has been of great value in fracture treatment from the time in the middle ages when a surgeon barber, who was called to see a French count suffering from a shattered leg tied one end of a rope to the patient s foot and the other end to a stone which was allowed to hang over the end of the bed It must be remembered that although the words are commonly used together, traction and suspension are distinct entities. Each may be used without the other

Suspension of an extremity is useful for improving the circulation by position and for allowing freer motion in the suspended part than would be possible if the patient had to lift the extremity against gravity Its use when coupled with traction is also to make the traction more efficient and to help in controlling the position of the fragments. Traction on the other hand regains length and helps to maintain the position obtained

For example an elderly but active woman came to the clinic for treatment of a badly broken wrist several days after the injury Good reduction at that time might be possible, but it would necessitate a long period of immobilization of the wrist and hand with a protracted after-period of disability It was wiser in that case to disregard the poor anatomy and bend every effort to regain useful function of the hand in as short a time as possible.

Next in importance to the evaluation of the patient is the form of treatment for which the doctor is best equipped Is he working alone in a small town with limited assistance and equipment or is he working in a large hospital with trained personnel and a smoothly running organization?

Finally comes the consideration of the type of fracture itself its special problems and difficulties.

Reduction and Splints.—Keeping these considerations in mind we can now discuss the possible methods of treatment the doctor has at his disposal. First in general usefulness and therefore in importance is the method of closed reduction under an anesthetic, either general or local followed by the application of some form of immobilization. Again it should be emphasized that the time for reduction is as soon after injury as possible in order to restore the broken bones to their normal position before the edema granulation tissue, and muscle spasm have made this too difficult. The malposition of the broken bones may impair the circulation by direct pressure on the vessels, and thus increase the swelling which will persist until normal position of the fragments has been restored "Wait until the swelling goes down is very dangerous advice. In almost all cases anesthesia should be used for the reduction because it relaxes the muscle spasm diminishes the amount of force necessary and gives the operator time to do the thorough job which is practically impossible if the patient is conscious and suffering pain The reduction should be done as gently as possible not by any fixed set of maneuvers but by those motions which will restore that particular broken bone to

constant care on the part of the doctors and nurses responsible for the patient. It is so easy for something to get out of place, for weights to rest on the floor or on projecting parts of the apparatus, for knots to catch in pulleys, for wrinkles to cause blisters Traction to be efficient, must be functioning twenty-four hours a day (Fig 3)

It is frequently possible to couple the two methods so far described, that is to apply traction for a period of time until

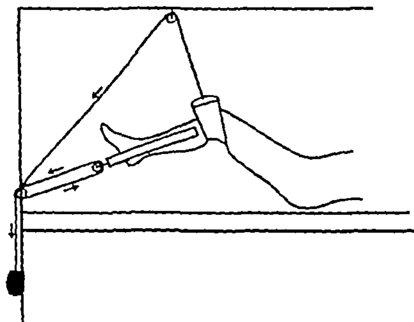


FIG 2—Russell traction.

full length has been obtained and then by manipulation slip the bone ends together There is no reason why the use of one method should preclude the use of another

The use of traction suspension necessarily means confinement in bed usually in a hospital. It is therefore an expensive process. Endeavor has been made recently by a combination of methods to allow the patient to be ambulatory The use of two wires inserted one above and one below the site of the fracture and held in place by circular plaster has

The same principle holds true for treatment by traction and suspension that holds in manipulative reduction i. e that the reduction must be accomplished as soon as possible. In other words the maximum weight needed to regain the length of the extremity should be applied at once and the position checked at frequent intervals by clinical and x-ray or fluoroscope examinations When reduction is accomplished the weight should be reduced to the amount necessary to maintain the position. No doctor would consider reducing a fracture manually by a series of manipulations done at twenty-four-hour intervals. Why therefore, should the at tempt be made to reduce a fracture by traction by adding weights at daily intervals, in the hope of obtaining a reduction by the end of a week? The principles underlying both methods are the same. The earlier the reduction the sooner the repair process can proceed unhindered

Traction can be obtained in two ways (1) By a pull on the skin by moleskin adhesive plaster or similar substances or (2) by a direct pull on the bone by means of pins tongs or wires inserted into or through the bone. The skin is unable to stand a pull of much more than 10 pounds so this method is obviously limited in its use It also is frequently uncomfortable and cannot be maintained over a long period because of irritation to the skin particularly in old people Skeletal traction on the other hand is efficient and apparently relatively comfortable. If properly applied it can be maintained for weeks. It is of importance to remember that the use of any form of skeletal traction must be accompanied by strict surgical technique to avoid possible infection

A simple form of traction, called the Australian or Russell method depends for its force on a double-pulley system and is effective and practical in certain fractures of femur and humerus (Fig 2)

The initial construction of the apparatus and the rigging-up of the patient in traction are but the first steps in the treat ment because a satisfactory result can be obtained only by

decision to operate should be reached as soon as possible, however as delayed open reductions when the bone fragments are soft and decalcified are difficult and not too satisfactory Operations to be successful should be done in most cases within the first week or ten days, or else should be postponed for months until the bone has become recalcified

The advisability of open reduction as a method of choice rather than necessity is still under discussion If the broken bones could be rigidly fixed by some form of internal splint so that the patient retained full function of the extremity ideal conditions for the healing of the fracture would be obtained With this in mind surgeons have attempted to devise operative means of reducing and retaining certain fractures by means of steel plates and screws, wires, bands, ivory pegs, etc. The dangers of the method are obvious for the bruised and injured tissues surrounding the broken bones are admirable media for bacteria, and an osteomyelitis as a result of operation is a disaster Adequate technique, skilled assistants, tested equipment and a smoothly running organization are absolutely essential for the success of the operative method

Compound Fractures.—There is one group of cases however in which opinion is unanimous that operation must always be done and at once. This is the group of compound fractures.

These are all potentially infected cases and the sooner they can be made surgically clean the less danger there is that infection will become established They should be considered as much of an emergency as a ruptured appendix. The principle of treatment consists in removing the dead and dying tissue and in the thorough cleansing of the wound to its depths This is done by careful débridement of the wound and thorough lavage with normal saline or sterile water The use of disinfectants in the tissues has been almost entirely given up because the mechanical cleansing action of inert fluid has proved adequate and less injurious to the soft

become very popular It allows the patient to leave the hospital after a few days Certain precautions are necessary in the insertion of wires for infection is a most unfortunate complication The use of this method has been satisfactorily applied to complicated fractures of the wrist to oblique fractures of the forearm and of the leg and other similar cases

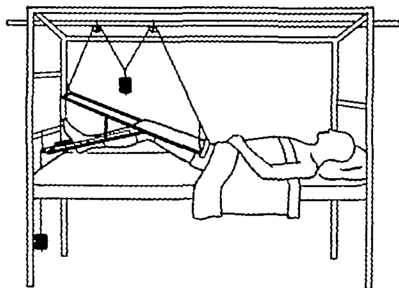


FIG 3.—Balkan frame and leg traction.

Open Reduction of Fractures.—Operative interference is necessary in cases where increasing swelling due to bleeding is jeopardizing the extremity or where there is interposition of soft parts between the fragments. It is the wisest treatment when satisfactory position cannot be obtained or maintained by other means. Open operation with repair of the torn soft parts and fixation of the bone fragments has for years been considered the best method of treatment for fractures of the patella and of the olecranon in which separation of the fragments has occurred because no closed method offers such good results. The

minimum but they usually exist to some extent Physical therapy in the form of heat, gentle massage, and the use of hot soaks or contrast baths may be started as soon as it is safe Such measures should never be carried out in the first days following reduction without the doctor s supervision It should also be remembered that such methods are only aids and the patient should be cautioned against relying too strongly upon them for they will not take the place of voluntary muscle action One-half hour three times a week will do very little for an extremity that is carefully protected from use during the rest of the time Wisely used however physical therapy methods can be of great assistance

More valuable however, are various forms of occupational therapy These may tax the doctor s ingenuity and inventive powers but are well worth the effort. Weaving knitting wood-carving jig-saw work and similar occupations have the advantage of focusing the attention of the patient on what he is making rather than on the action of his injured limb with the result that the coördination is far better A patient is much more likely to play nine holes of golf five times a week when prescribed by his doctor than to walk the same distance with no objective. The walk is boring but golf is interesting Occupational therapy can be carried on in the home several hours a day and helps the patient to return to his normal activities faster than almost any other form of treatment.

parts. After the wound has been rendered as surgically clean as possible the fracture can be treated as the surgeon thinks wise. If any form of internal fixation is used the wound must be left open because of the irritating action of a foreign body should infection ensue.

Before a patient with a compound fracture reaches the operating room however, certain things must be done. When the case is first seen the wound should be immediately covered by a sterile dressing No attempt at cleansing should be made at the time for it can be carried out more quickly and carefully and with less shock to the patient when he is under an anesthetic. It is considered wise not to pull projecting bone fragments back into the wound because of the danger of spreading the contamination The extremity should be splinted therefore without traction The general condition of the patient must be watched and supportive measures such as morphine heat, intravenous fluids, etc., given if necessary Tetanus antitoxin should be given in all cases of compound fracture and in some districts gas bacillus antitoxin as well

If it is possible to obtain *x*-ray pictures of the fracture without delay and without undue disturbance of the patient, they should be taken before the operation as the films can be of great value to the operator

The shorter the interval between injury and operation the better will be the results.

REHABILITATION

Under ideal conditions where the patient has been able to continue the use of the extremity while the fracture is healing rehabilitation is not necessary Unfortunately such ideal conditions are practically never obtained and weakened muscles, stiffened joints and poor circulation are present after the immobilizing apparatus has been removed As has been said before, these conditions may be reduced to a

by direct pull on the rope and the leg straightened out The pull should not be relaxed at any time The ring of the Thomas splint can then be slipped over the foot and the splint gently pushed up the leg until the ring rests against the ischial tuberosity Care must be taken in an unconscious patient to avoid pressure against the scrotum or labium The two ends of the traction rope can then be tied at the end of the splint and traction increased by twisting the rope with a

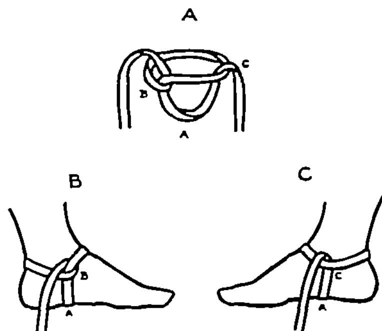


FIG. 5.

stick the so-called "Spanish windlass method A snug bandage tied around both the extremity and the splint at the mid-thigh above and below the knee and in the middle of the leg will hold the limb firmly in place and the patient can be transported with relative comfort. Care must be taken not to allow the patient s heel to rest on mattress or stretcher This can be avoided by supporting the end of the splint on a folded pillow or a similar rest. The upper extrem-

CHAPTER V

DETAILS OF TECHNIQUE IN TREATMENT OF FRACTURES

THE APPLICATION OF EMERGENCY SPLINTS

A THOMAS splint (Fig 4) can be simply and quickly applied by an individual alone if he has had practice. As the patient lies on the ground the bandage to be used for

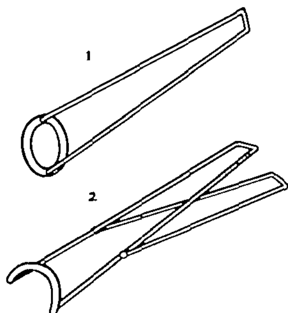


FIG. 4.—1 Emergency splint 2, half-ring splint with footpiece for suspension.

traction should first be tied around the ankle with the shoe left in place and adequate padding placed between the tie and the extremity Various knots can be used for this purpose one of the simplest is shown in the illustration (Fig 5) With the bandage or rope in place traction can be exerted

sary to have the ring so placed that adduction will not cause pressure on the axillary vessels and nerves The splint should be applied with the arm at 90 degrees' abduction If the limb is later to be brought to the side for transportation the arms of the splint should be placed in the antero-posterior plane (Fig 6) If the limb is to be brought forward at 90 degrees' flexion *i e*, tied to the *roof of an ambulance* the arms of the splint should be applied in the superior-inferior plane (Fig 7) Both arm and leg Thomas splints form very satisfactory protection for fractures of the shafts of the long bones

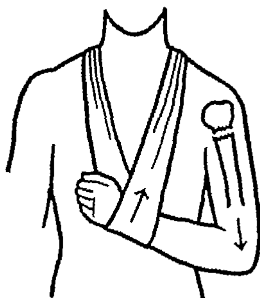


Fig. 8

If a Thomas splint is not available the doctor should be able to improvise from the material at hand a means of immobilization. Ironing boards, shelves, even cellar doors can be utilized A child with a fractured femur was safely and comfortably transported to a hospital on a bookshelf Traction was applied by a bandage tied around the ankles and passed snugly around the back of the board (which was slightly longer than the patient) to end in a loop under the child s shoulders.

its can be splinted in the same manner The arm splint is hinged to allow the arm to be placed at the side. It is neces-

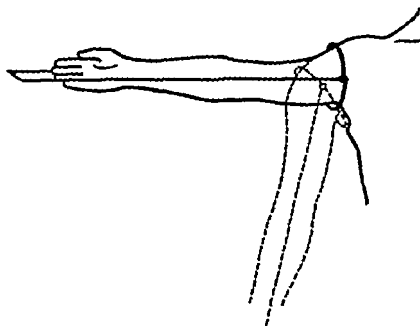


FIG 6.

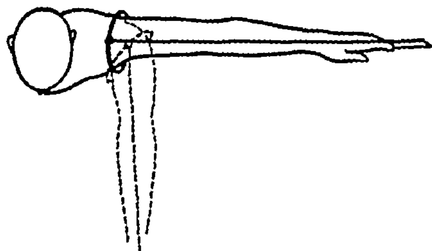


FIG. 7

after the removal of the plaster-of Paris appliance and before the injured part has regained full strength If the adhesive plaster is to be applied directly to the skin the surface should be shaved and cleaned Tincture of benzoin applied directly on the surface to be strapped will protect the skin from irri

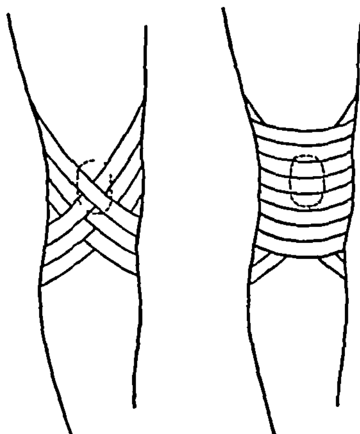


FIG. 10.—Knee strapping

tation and make the adhesive plaster stick better There are many different forms of ankle strapping most of them good A simple type as shown in the illustration consists of two 2-inch strips extending from the outer side of the knee around the instep to the inner side of the knee and held in place by narrower strips around the ankle (Fig 9) The foot

For fractures of the wrist or ankle padded board splints are satisfactory For injuries around the shoulder it is frequently wise to use a sling and swathe for temporary immobilization. It should be remembered that in these cases a sling should not support the elbow but merely suspend the wrist so that the weight of the arm may act to produce traction (Fig 8)

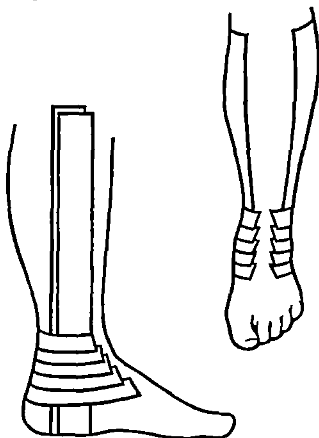


FIG 9 —Ankle strapping.

ADHESIVE STRAPPING

The use of adhesive plaster for a support for an injured joint is very common. It can also be used in fracture cases

stockinette wrapped firmly with adhesive plaster To make this removable it can be split, bound with adhesive, and laced with a shoelace or tape through holes punched in the edge (Fig 11) Similar removable dressings can be made for an ankle

PLASTER-OF-PARIS SPLINTS AND CASINGS

It is not within the scope of this book to describe all the types of plaster-of-Paris dressings. Each surgeon has his own techniques, but certain hints in the use of this material may be found helpful The making of a splint is a simple procedure if the commercially prepared plaster-of Paris bandages are used The required length, measured on the uninjured extremity is ascertained and the dry bandage unrolled back and forth until the desired number of layers is reached It is then dipped in a pail or basin of warm water for the length of time necessary for the particular make of bandage and spread out on a smooth flat surface. Care should be taken to rub the wet plaster thoroughly in order that the gauze be completely impregnated before applying it to the patient. The plaster may be covered by a layer of Canton flannel or stockinette to protect the skin The roll of prepared plaster may be soaked before it is unrolled and the layers made from the wet plaster If this method is used each layer must be rubbed in as it is laid down The wet splint is then bandaged firmly in place on the extremity and allowed to dry When the plaster has hardened the bandages should be cut off as the dampness may cause the gauze to shrink and cut into the skin. The splint should always be rebandaged before the patient is permitted to leave Great care should be taken not to allow any motion while the plaster is setting otherwise a "hinged splint or casing will result

If padding is used over bony prominences under a circular plaster it should be so cut that it surrounds the prominence instead of pressing directly upon it (Fig 12) The plaster

should be at right angles to the leg and either in mid-position or slight inversion No strapping of an ankle should be circumferential because of the danger of swelling of the dependent part. Strapping to be effective must be put on with considerable firmness not just laid on Satisfactory strapping for the knee is shown in the illustration (Fig 10)

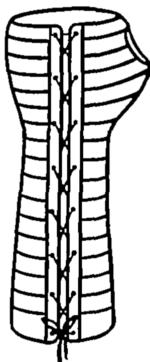


FIG. 11.—Removable support for the wrist.

Strapping for the chest should always go beyond the mid line both in front and in back, otherwise it is ineffectual It is difficult to strap a woman s chest with adhesive plaster directly applied to the skin A circumferential flannel binder held up by shoulder straps and then covered by 4-inch adhesive applied securely gives a very satisfactory support. This is also more comfortable for men with hairy chests. A support for the wrist can be made by the use of snug-fitting

to cut into the soft parts as in mid-calf or mid-forearm and yet not so far as to interfere with motion in the adjacent joints A gauntlet for a wrist should extend from the mid-palmar crease to about 1 inch below the elbow A plaster boot should extend from the toes to about 1 inch below the knee It is more comfortable for the patient if any plaster which includes the foot is carried to a little beyond the tip of the toes on the plantar surface and to the metatarso-phalangeal joints on the dorsal (Fig 13) This gives room for motion of the toes and supports them on the plantar surface thereby preventing cutting at the edge of the plaster

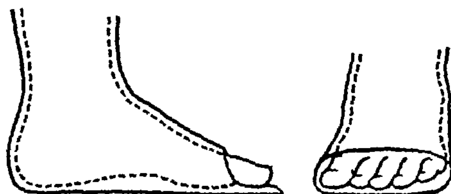


Fig. 13.

Leg casings which do not include the foot tend to slip up and down This can be remedied by placing two long strips of adhesive plaster on the skin of the medial and lateral aspects of the extremity The plaster-of Paris is then applied over the strips the ends of which are turned back and incorporated in the casing Care must be taken to get the plaster high enough All splints and casings should have smooth edges to avoid irritation of the skin

Any casing that is applied for the immobilization of a recently reduced fracture or of an injury likely to cause further swelling must be split for its entire length Failure to observe this precaution may result in disastrous impairment of the

should be applied smoothly and constantly rubbed in with careful molding to the contours of the part. Plaster casings should always be so applied that they extend far enough not

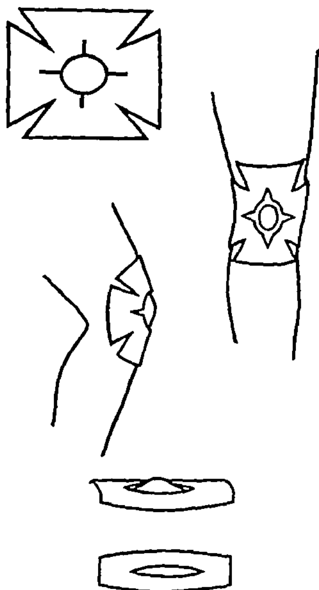


Fig. 12.—Types of felt padding.

FIG. 14.—Site for aspiration of the elbow joint.

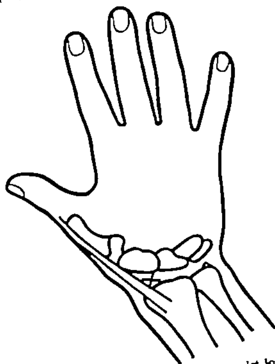


FIG. 15.—Site for aspiration of the wrist joint.

circulation If for any reason it is felt unwise to split the plaster-of Paris the patient should be kept under constant observation until the danger of further swelling is over

Various motor-driven saws and knives have been invented to aid in the removal of plaster jackets, spicas, and extremity casings However these are not always available The most useful and the most foolproof instrument is the two-handled plaster-cutting instrument with a cutting saw tooth upper blade and a dull flat lower blade to slip between the plaster and the skin. An old scalpel or a razor blade is helpful in cutting around corners but must be used with caution Hydrogen peroxide will soften the plaster somewhat, but usually patience and persistence applied to the plaster-cutting instrument will suffice to remove any casing

ASPIRATION OF JOINTS

Aspiration of a joint is a very valuable therapeutic measure in cases where fractures into the joint have caused a hem arthrosis with resulting pain and disability. It may be safely carried out if done under strict surgical precautions. The joint to be aspirated should be shaved cleaned and prepared as for an operation The operator should use sterile gloves. At the site chosen for the insertion of the needle a small bleb is made in the skin with novocaine An incision is made in the bleb with a sharp-pointed scalpel so that skin contamina tion is not carried down into the depths by the aspirating needle. The needle used for skin injection is discarded a second needle longer than the first is inserted and the novocaine is injected down to and into the capsule of the joint. After a minute or two to allow the novocaine to take effect an aspirating needle of large bore is inserted into the joint cavity and the fluid removed An elbow joint may be aspirated on the postero-lateral aspect in the mid-point of the triangle formed by the tip of the olecranon the lateral epicondyle and the radial head (Fig 14) The wrist joint

of the fracture is attempted Failure to do this causes considerable pain to the patient and may diminish the efficacy of the anesthesia.

TRACTION SUSPENSION APPARATUS

There are many different types of frames in use each with its own peculiarities. However there are certain details which are common to them all In setting up a frame for use with skin traction it is better to apply the adhesive material to the skin before the rest of the apparatus is

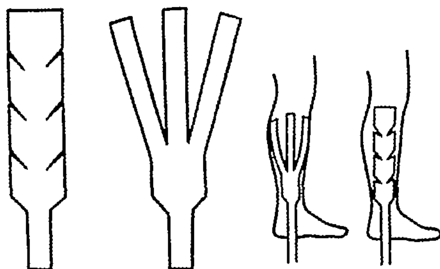


FIG. 17

assembled That allows time for the plaster or flannel to become firmly adherent to the skin before the weight is attached to it. The adhesive plaster must be absolutely smooth as a wrinkle will cause an irritation or blister in the skin To make it fit it should be cut in such a way as not to weaken its tensile strength (Fig 17) It should not press on any bony prominences but the spreader on the other hand should not be so much wider than the extremity that it will tend to

may be aspirated in the dorsal surface just medial to the tendon of the extensor longus pollicis (Fig 15) The knee may be aspirated on either side of the patella at its upper or at its lower margin (Fig 16) The ankle may be aspirated at a point on the antero-lateral aspect about 2½ cm cephalad to the tip of the fibula and 1 cm medial

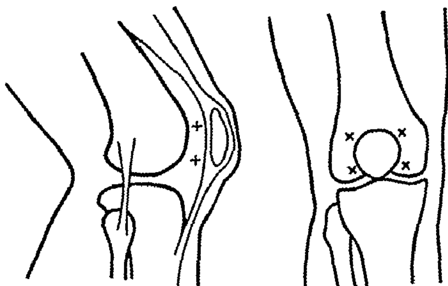


FIG. 16 —Sites for aspiration of the knee joint.

LOCAL ANESTHESIA FOR REDUCTION

The technique for the injection of novocaine for the reduction of a fracture is similar to that used in aspirations and similar precautions should be observed The site for injection should be directly over the fracture The injecting needle inserted after the skin nick, should go directly into the hematoma which always surrounds the bone ends in the first few hours after injury Ten to 15 cc. of a 1 or 2 per cent solution of novocaine should then be injected into the hematoma It is important to allow five or ten minutes to elapse after the injection of the novocaine before any manipulation

Ropes must run freely through the pulleys. Supporting swathes must be smooth and maintain an even pressure. If much weight is being used, shock blocks to counteract the pull will help to prevent the patient from being pulled out of bed. For instance, if there is great traction on the lower extremity the foot of the bed should be elevated by shock blocks. If there is considerable traction on the arm, the side of the bed should be raised to keep the patient from being pulled too near the edge.

Some form of appliance should be used to prevent foot-drop. An adhesive plaster sole attached by a rope through a pulley to a light weight will work very satisfactorily.

No matter what type of rope is used for rigging up the apparatus all knots should be bound with adhesive tape to prevent slipping or fraying. The sudden collapse of suspension is frightening to the patient and may have a disastrous effect on the fracture.

When it is desired to remove the wire, one end can be cut flush with the skin by a pair of wire cutters. The tip is then painted with iodine or alcohol and the remaining end grasped by a clamp and pulled steadily. No anesthesia is necessary. If the wire has been in place for some time it is usually extracted with very little effort.

strip the adhesive upward (Fig 18) To hold the adhesive firmly to the skin an elastic bandage should be snugly and smoothly applied The upper inch of plaster, however, should remain exposed to view so that a glance will show if it is beginning to slip



FIG 18.—Solid line shows footrest spreader

If skeletal traction is preferred the wire should be introduced through a nick in the skin under strict aseptic technique. Either a motor drill or a hand drill can be used and any number of gadgets have been devised to hold the wire rigid as it goes into the bone. The skin should be cut at the point of emergence as well as at the point of entrance so that there is no undue tension at the skin edge A small cotton collodion dressing is all that is needed for the wound It should be remembered that wire should always be inserted from the dangerous side, *i. e* where there are structures to be avoided because the point can be placed in the bone either by direct vision or blunt dissection The point of emergence, however is less controllable For example at the elbow the wire should be inserted at the medial aspect of the olecranon as the ulnar nerve can thus be avoided At the lower end of the femur the medial side is again the side of choice for the insertion of the wire so that there will be no danger of the emerging point entering the adductor canal (Hunter's canal)

After either form of traction has been applied to the extremity the apparatus must be so lined up that the direction of pull is parallel to the axis of support. The traction rope should be sufficiently short so that there is no danger of the weights resting on the floor or on a bar of the bed

PART II

THE UPPER EXTREMITY

PERCENTAGE OF OCCURRENCES

The figures quoted are based on 10 749 fractures and dislocations seen during the years 1929 to 1937 inclusive on the Fracture Service of a voluntary hospital They comprise only those cases treated shortly after injury and do not include those who came in for treatment of non-union or other late complications As there is no emergency ambulance attached to the hospital the percentage of lower extremity injures is undoubtedly smaller than that of a hospital with such an ambulance service The wards (with a capacity of 29 beds) and the out-patient department are under the same staff members so that there is a unified system of records and diagnoses

	Per cent of all fract	Per cent of all disloc.	Per cent of total injuries
Injuries to the shoulder girdle.			
1 Fractures of the clavicle	5 01		4 52
2 Fractures of scapula	0 55		0 49
3 Dislocations of clavicle			
Acromio-clavicular joint		7 23	0 71
Sterno-clavicular joint		1 73	0 17
Injuries at the shoulder-joint.			
1 Fractures of upper extremity of humerus.			
Anatomical neck	0 25		0 22
Surgical neck	2 13		1 91
Separation of epiphysis	0 20		0 18
Fracture of greater tuberosity	1 29		1 16
Fracture of lesser tuberosity	0 01		0 000
2. Dislocations of upper extremity of humerus		23 23	2 21
Fractures of shaft of humerus	1 43		1 29

CHAPTER VI

INJURIES TO THE SHOULDER GIRDLE

FRACTURES OF THE CLAVICLE.

Occurrence—A common form of injury, particularly in children this fracture is usually due to the indirect trauma of a fall on the outstretched arm or on the shoulder, less frequently to a direct blow

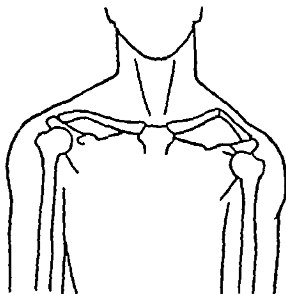


FIG. 19

Displacement.—The clavicle acts as the anterior supporting strut to the shoulder Therefore when the fracture occurs in the shaft at the most frequent site of break, *i e.*, the junction of the middle and outer thirds where the two curves of the bone unite the shoulder tends to droop downward forward and medially (Fig 19) Displacement of

	Per cent of all fract.	Per cent of all disloc.	Per cent of total injuries.
Injuries at the elbow-joint.			
1 Fractures of lower extremity of humerus.			
Supracondylar or diecondylar	2 47		2 23
T or Y fractures	0 19		0 18
External condyle	0 60		0 54
Internal condyle	0 16		0 15
Separation of epiphysis without displacement	1 07		0 96
Internal epicondyle	0 69		0 62
2. Fractures of upper extremity of radius.			
Fractures of radial head	2 62		2 27
Fractures in neck of radius	0 54		0 48
Separation of epiphysis	0 29		0 26
3. Fractures of upper extremity of ulna.			
Fractures of olecranon process	0 96		0 87
Fractures of coronoid process	0 53		0 47
4. Dislocations at the elbow		16 57	1 60
Injuries to the forearm.			
1. Fractures of the radius and ulna	5 47		4 94
2. Fractures of a single bone	6 76		6 11
Injuries at the wrist.			
1 Fractures of the lower end of radius.			
Colles' fractures	7 63		6 89
Reverse Colles' fractures	0 01		0 009
Seperation of lower radial epiphysis	3 32		3 00
2. Fractures of carpus.			
Fractures of scaphoid	2 13		1 91
Fractures of other carpal bones	0 37		0 33
3. Dislocations.			
Dislocations of lunate		0 87	0 08
Injuries to the hand.			
1. Fractures of the first metacarpal	1 57		1 43
2. Fractures of the other metacarpals	5 18		4 69
*3. Fractures of the phalanges	5 73		5 17
4. Dislocations			
Dislocation of interphalangeal and metacarpo-phalangeal joints		9 44	0 91

* Computed as per number of patients, not number of fractures.

CHAPTER VI

INJURIES TO THE SHOULDER GIRDLE

FRACTURES OF THE CLAVICLE

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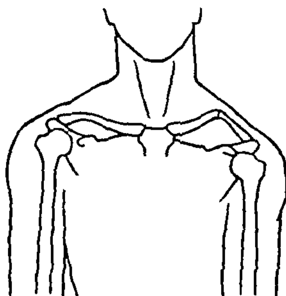


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the fragments is caused by the fracturing force and by the weight *of the upper extremity* There may be *overriding* or especially in the incomplete fractures of childhood angulation with the apex of the angle pointing upward (Fig 19) Fractures in the outer third may show no displacement if the coraco-clavicular (conoid and trapezoid) ligaments are intact, or may be displaced upward simulating an acromio-clavicular dislocation (*q v*) Injuries at the inner third

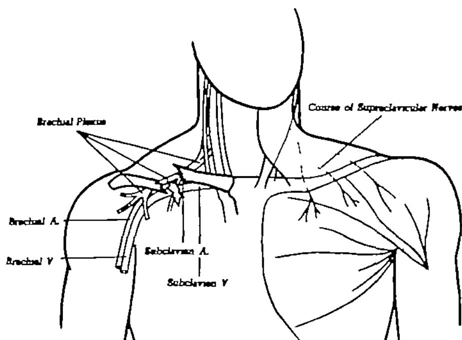


FIG 20.

rarely show displacement due to the restraining influence of the costo-clavicular (rhomboid) ligament.

Diagnosis —Due to its subcutaneous position the clavicle is easily palpated throughout its extent and the diagnosis of fracture is usually easy Irregularity of bony contour localized tenderness and disability should be sufficient to suggest such an injury *X*-ray pictures are always essential to confirm the clinical findings.

Pathology —Swelling and ecchymosis may be minimal or moderate depending on the amount of displacement of the fragments with the resultant tearing of the soft parts Because of the close relationship of the platysma to the bone the muscle fibers are occasionally pierced by a projecting fragment and may become interposed between the broken ends Injury to the supraclavicular nerves may occur and less frequently injury to the underlying brachial plexus (Fig 20) The latter is most often associated with a direct blow on the clavicle depressing the fragments More rarely damage to the subclavian vessels has been reported

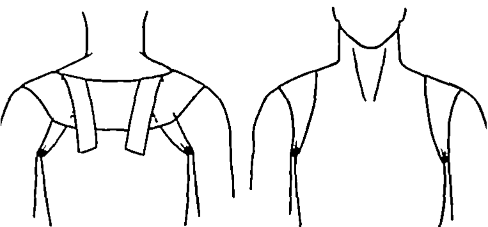


Fig 21

Treatment.—The shoulder must be held outward upward and backward to restore as far as possible the length and contour of the clavicle at the same time the function of the extremity should be limited to a minimal degree Many different types of apparatus have been described for this purpose

Green-stick fractures in children and fractures without displacement in adults can be held satisfactorily by plaster-of Paris shoulder splints which are carefully padded and molded under the axillæ (Fig 21)

Complete fractures with slight overriding can be reduced manually under local or general anesthesia, but the reduction is often difficult to maintain as the fracture line is frequently oblique. The T splint or one of the various modifications of it will frequently hold the position satisfactorily (Figs. 22 and 23) Patients with markedly displaced fractures, especially those with loose fragments, are best treated in bed

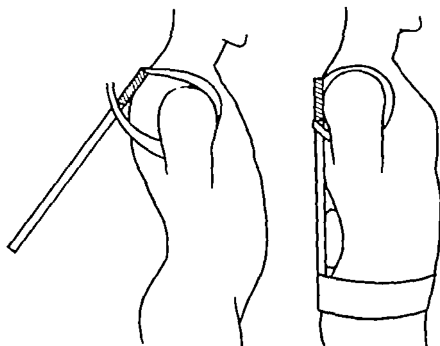


Fig 22.

with traction on the abducted arm (Fig 24) Open reduction is rarely necessary except in cases where interposition of muscle fibers makes reduction impossible or where nerve or blood vessel injury accompanies the fracture.

Whatever form of treatment is used active motion of the hand and elbow should be insisted upon from the beginning Shoulder motion should be encouraged within pain limits and steadily increased A sling should be used for the first

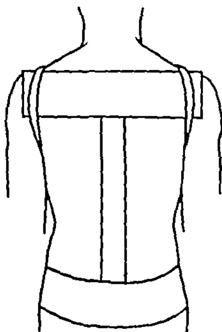


FIG 23

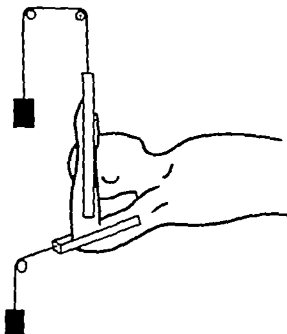


FIG. 24.

few davs only and should be removed occasionally to allow elbow and shoulder motion

Certain types of treatment are encountered so frequently that mention of them is necessary The Velpeau bandage does not reduce the fracture but tends to increase the deformity It does not allow motion of the extremity For these reasons it is strongly condemned The Sayre dressing if applied sufficiently tightly may reduce the fracture but at the expense of motion of the arm and great discomfort to the patient from the cutting of the adhesive straps

Time of Immobilization.—The simple forms of fracture will usually heal sufficiently to be freed from apparatus in three weeks. The comminuted type however may need some form of retaining splint for six weeks and in rare cases even longer

Prognosis.—Bony union is the rule with excellent function even in cases with considerable deformity

Summary —

- Frequent occurrence in children
- Characteristic deformity—forward downward and inward displacement of shoulder
- Treatment—reduction and appliance holding shoulder back up and out
- Excellent healing usual
- Good function in spite of deformity

FRACTURES OF THE SCAPULA.

Occurrence —These infrequent injuries are usually the result of direct violence for example a blow from a swinging girder Indirect violence may be responsible for a certain number especially of fractures of the scapular neck.

Displacement.—Fractures may occur in the body with or without involvement of the scapular spine through the neck and glenoid through the acromion and much less commonly through the coracoid Fractures through the

body may be transverse oblique or stellate. They show usually little or no displacement of any significance because of the enveloping muscles If the break involves the neck, the glenoid may be depressed and displaced inward due to the injuring force and the weight of the extremity with a resulting flattened appearance of the shoulder (Fig 25) Acromial fragments are apt to be pulled downward by the

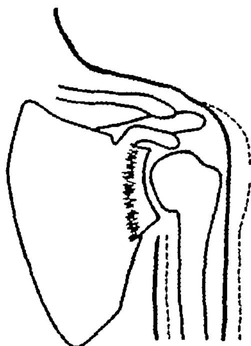


FIG 25.—Fracture of scapular neck with flattening of the shoulder Dotted lines indicate the normal contour

weight of the arm pulling on the deltoid The coracoid may show no displacement or may be depressed by the muscles attached to it if the coraco-clavicular ligaments are torn

Diagnosis —Tenderness over the body of the scapula swelling and pain on motion of the shoulder are suggestive signs. Occasionally bony irregularity can be palpated along the borders of the bone and in some cases crepitus may be felt during the process of examination

Commolli s sign a triangular swelling corresponding in size to the scapular body and caused by hemorrhage from the broken bone confined by soft part attachments, is considered by some to be pathognomonic of scapular fracture when it is seen (Fig 26) It is not present when extensive lacerations of the soft parts permit escape of the blood into the surrounding tissues.

A flattened shoulder with prominent acromion but with the humeral head still in the glenoid is strongly suggestive of fracture of the scapular neck if accompanied by the usual signs of tenderness swelling and limitation of motion

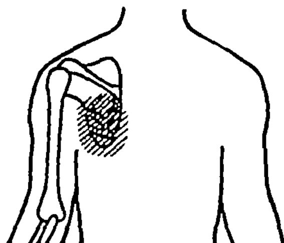


FIG. 26.—Commolli's sign for fracture of the scapula.

Occasionally bony irregularity or actual displacement of the fragment can be felt in acromion and coracoid breaks, but usually local tenderness and swelling are the only leads and x-ray pictures are necessary to establish the diagnosis.

Pathology —Because the bone lies as a plate between muscle layers, a fracture is always accompanied by some degree of contusion and laceration of the soft parts. Infiltration of blood into the tissues followed by fibrosis with the resulting diminution of function is characteristic. Nerve and large

vessel lesions are uncommon and associated only with extensive injury

Treatment.—In fractures of the body of the scapula, therapeutic measures should be directed primarily toward the soft part pathology as slight permanent displacement of the fragments does not interfere with function Therefore physical therapy in the form of heat, light massage, muscle stimulation etc., to get rid of the extravasation of blood as soon as possible should be instituted early Rest in bed when feasible with the arm held abducted in suspension is valuable to allow active motion within pain limits If bed rest is not practical the extremity can be supported on some form of aëroplane splint. In undisplaced fractures where the soft part involvement is negligible, adhesive plaster strapping over the scapula may be used

Fractures of the neck and glenoid can be treated by traction on the arm in the abducted position. Early active motion and physical therapy are of great importance to prevent adhesions and subsequent loss of function

Acromial and coracoid fractures should be treated in such a way that the weight of the arm is supported and the forearm flexed to relax the pull on the fragments. Adhesive plaster may be used as described in the treatment for acromioclavicular dislocations.

Operation is rarely if ever necessary except in compound fractures.

Time of Immobilization.—Methods of support, adhesive plaster sling etc. should be maintained from two to four weeks in mild injuries, from four to six weeks in those that are more severe

Prognosis.—Return of function should be complete at about three months in spite of persistent bony deformity

Summary —

Infrequent injuries without characteristic deformity

Soft part damage of prime importance and treatment directed toward it.

Persistent deformity not incompatible with function

DISLOCATIONS OF THE CLAVICLE.

Acromio-clavicular Joint.—**Occurrence**.—Dislocations at the acromio-clavicular joint are fairly common and are usually caused by a fall or blow on the point of the shoulder depressing the acromion process Such injuries are frequent in football

Displacement.—By far the most frequent displacement is an upward shift of the outer end of the clavicle to a varying distance above the acromion In some cases the clavicle may slip behind the acromion Downward displacement is extremely rare

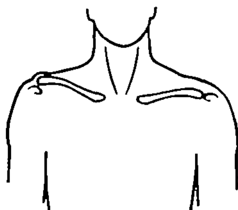


FIG 27

Diagnosis.—The shoulders appear asymmetrical with a prominence of the outer end of the clavicle on the injured side (Fig 27) This prominence is increased by a downward pull on the arm Tenderness is localized over the acromio-clavicular joint and there may be moderate swelling and ecchymosis.

X-ray films are of the utmost importance to distinguish between complete (*i e* with torn coraco-clavicular ligaments) and incomplete dislocations (with frayed or intact coraco-clavicular ligaments) The *x*-ray plates should be taken with the patient standing or sitting his arms hanging

by his side and both shoulders included on the same plate In complete dislocations there will be an appreciable increase in the space between the clavicle and the coracoid on the injured side as compared with the uninjured side In partial dislocations there will be no difference in the coraco-clavicular distance on the two sides though the injured acromio-clavicular joint will appear widened

Pathology —In complete dislocations there is always rupture of the coraco-clavicular ligaments as well as of the acromio-clavicular joint The torn ends are separated and tend to curl under thereby preventing firm healing In partial dislocations only slight tearing or stretching of the coraco-clavicular ligaments occurs (Fig 28 *A*) Nerve and vessel injuries are rare complications

Treatment.—Because of the pathology operative repair is advised for complete dislocations Some method should be employed which will replace the torn ligaments and hold the clavicle to the coracoid (silk tape fascia lata peroneus longus tendon) (Fig 28 *B* and *C*)

Incomplete dislocations may be treated by an adhesive plaster dressing over the shoulder depressing the clavicle and under the elbow lifting the arm (Fig 29) Careful padding over the olecranon is necessary to avoid pressure sores Active use of the hand and forearm should be encouraged

Time of Immobilization.—Some form of dressing should be maintained for from three to four weeks

Prognosis.—Functional results are almost always excellent in the incomplete and in the repaired complete cases though visible deformity may persist. Pain and weakness of the shoulder may be the result of an unreduced complete dislocation.

Summary —

Characteristic deformity of prominence of outer end of clavicle

Incomplete dislocations without complete rupture of coraco-clavicular ligaments treated conservatively

Complete dislocations with complete rupture of coraco-clavicular ligaments treated operatively
X-ray picture of both shoulders on same plate essential

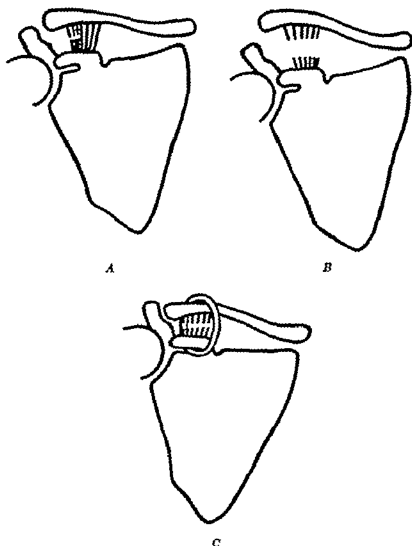


FIG. 28.

Sterno-clavicular Joint.—**Occurrence**.—These cases are infrequent. They may be due to an indirect violence which

forces the shoulder backward or inward, causing an anterior dislocation of the inner end of the clavicle or more rarely to a direct blow on the sternal end of the bone, displacing it backward

Displacement.—The more usual type is a forward and upward dislocation with the clavicle anterior to and overlying the sternum It may also be pulled somewhat down-

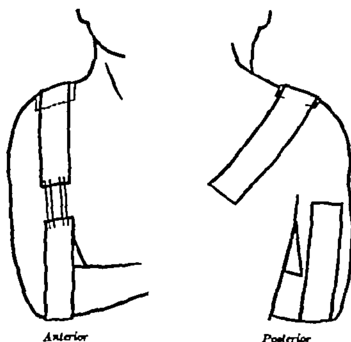


FIG 29 —Dressing for incomplete acromio-clavicular dislocation.

ward (Fig 30) Less frequently the sternal end of the clavicle lies posterior to the sternum.

Diagnosis—A visible and palpable mass at the sterno-clavicular joint is characteristic. Moderate pain and limitation of function also occur but in many cases are not striking If a posterior dislocation is present the prominence of the sternal border and the posterior position of the clavicle are easily seen and felt.

Pathology.—There is always a stretching or tearing of the sterno-clavicular ligaments and joint capsule. The fibro-cartilage usually remains attached to the clavicle. If the displacement is posterior there may be pressure on the trachea, esophagus or vessels.

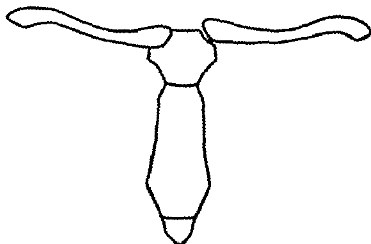


Fig. 30.

Treatment.—Reduction of the anterior dislocations can usually be accomplished by pulling the shoulders outward and backward, at the same time exerting pressure over the inner end of the clavicle. A figure-of-eight dressing around the shoulders with a pad and adhesive strapping over the affected joint will serve as a dressing (Fig. 31). The maintenance of complete reduction is difficult and frequently impossible. Operative repair may be necessary in long standing cases with persistent symptoms.

Posterior dislocations may be reduced by forcing the shoulders outward and backward. If this is not successful operative reduction may be necessary. A figure-of-eight dressing should hold the reduction satisfactorily.

Time of Immobilization.—Some form of protection should be maintained for from three to five weeks.

Prognosis.—A moderate prominence is almost inevitable but the function of the extremity is usually complete within a few weeks of the injury

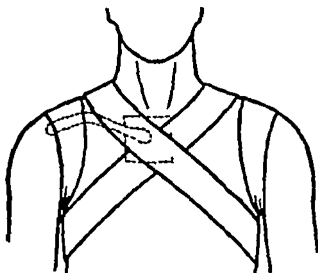


Fig 31

Summary —

Prominence of inner end of clavicle.
Difficulty of reduction and maintenance of position
Deformity rarely a handicap to function.

CHAPTER VII

INJURIES AT THE SHOULDER-JOINT

FRACTURES OF THE UPPER EXTREMITY OF THE HUMERUS

Anatomical Neck.—**Occurrence**—This is an uncommon type of fracture and is rarely seen without an associated dislocation (*q v*) High surgical neck fractures are frequently mistaken for it (Fig 32)

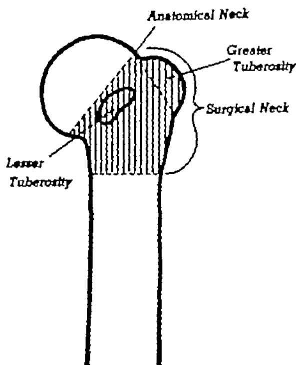


Fig. 32.

Displacement.—This may be negligible especially if the fracture is incomplete or impacted

Diagnosis—Pain and disability, swelling and tenderness around the shoulder with ecchymosis suggest a fracture of the upper end of the humerus, but x-ray plates are necessary to establish the exact site

Pathology—Because of the limited blood supply to the head fragment late changes may take place with resulting flattening of the head or with failure of union

Treatment.—The earliest possible restoration of motion should be the aim A sling and body swathe for the first few days with frequent periods of active motion heat and gentle massage followed by graded exercises can be used in those cases where there is little displacement When gross displacement has occurred closed reduction with maintenance of position by traction suspension or some form of ambulatory splint may be attempted Operative removal of the head fragment may be necessary

Time of Immobilization.—These fractures unite fairly rapidly and all protection should be removed in most cases in from three to five weeks

Prognosis.—This depends largely on the extent of the circulatory damage that has occurred Abduction is liable to be permanently limited and painful

Summary—

Rare injury usually associated with dislocation
Late deformity possible due to poor blood supply
If no displacement active motion as soon as possible

Surgical Neck.—**Occurrence**—These injuries constitute by far the largest number of fractures of the upper end of the humerus. They frequently occur in adults past middle life and are caused in the majority of cases by a fall or blow on the arm

Displacement.—Impaction may be present with little or no displacement. On the other hand there may be marked angulation or separation of the fragments. The proximal fragment may be abducted if the greater tuberosity is intact allowing the pull of the supraspinatus to act (Fig 33) If the

greater tuberosity is torn off however, the head fragment may be actually adducted and internally rotated by the subscapularis. The distal fragment may be pulled inward by the pectoralis and teres major and upward by the biceps and deltoid. The fracturing force however undoubtedly plays a large part in the resulting displacement.

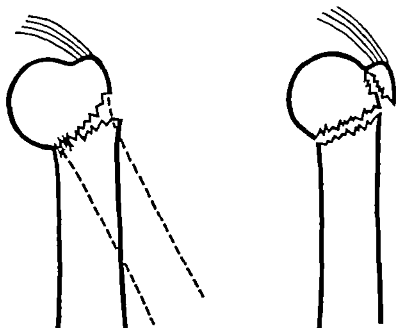


FIG. 33.

Diagnosis —All elderly patients who complain of pain and disability in the shoulder following a fall should be suspected of having a fracture especially if there is spreading ecchymosis on the inner side of the arm and on the chest wall twenty-four to forty-eight hours after injury If there is measurable shortening of the arm deformity and no motion of the head when the shaft is gently rotated the diagnosis of a complete fracture is obvious. *X* ray pictures in two planes if possible if not at least in stereo should always be obtained

Pathology.—Injury to the brachial plexus and axillary vessels from the upper end of the lower fragment may occur if the displacement is great (Fig 34) Luckily this is a very rare complication. Soft part damage is however very frequent with hemorrhage into the surrounding tissues and tearing of bursal walls.

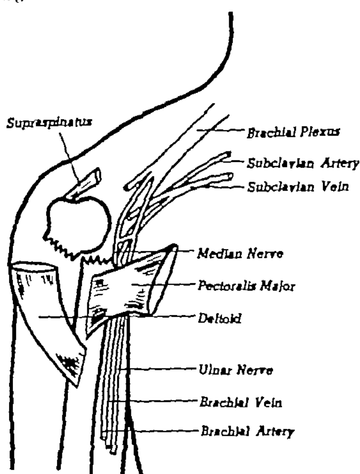


FIG 34

Treatment.—Every effort should be made to regain motion as soon as possible and soft part damage should be combated from the beginning to minimize scarring and fibrosis. The position of abduction should not be used as a routine procedure unless there is a definite indication for it.

When there is impaction even with considerable malposition of the fragments treatment by sling and swathe (Fig 35) with pendulum exercises from the first day heat and gentle massage will give excellent functional results despite bizarre *x* ray pictures If the patient can enter the hospital for suspension and more intensive physical therapy the result may be obtained more rapidly but the ambulatory treatment under constant supervision is extremely satisfactory

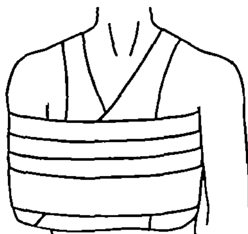


Fig 35.

In cases with displacement, reduction may be accomplished under general anesthetic and held by a sling and swathe if the position is easily maintained or by traction and suspension if the fragments tend to slip A wire through the lower end of the humerus or through the olecranon is a satisfactory form of traction if skin traction is insufficient to hold the required position The position of maintenance depends on the original displacement which must be carefully studied If the head fragment is adducted or in the mid position abduction of the arm will often give a bad angular deformity

An aëroplane splint may be used if abduction is indicated when bed treatment is for some reason impossible but these appliances are difficult to fit accurately to the individual.

They do not allow the use of extensive physical therapy however, nor motion of the elbow wrist and fingers. Plaster-of Paris shoulder spicas are strongly condemned Their use may give a pretty x ray picture but will necessitate months of treatment to restore function

Time of Immobilization.—Impacted fractures need to be protected by a sling and swathe for a week or ten days and by a sling for another two weeks or so Fractures that have required reduction should be protected for from four to six weeks with active motion within pain limits during that time Fractures in traction may be placed in sling and swathe when the head and shaft fragments move together

Prognosis.—Functional return is often surprisingly good in from four to six months in spite of strikingly poor x-ray results.

Summary—

- Frequent injuries in adults past middle life
- Deformity dependent on fracturing force and on muscle pull
- Treatment directed toward functional rather than anatomical restoration.
- Immobilization in abduction indicated only if head fragment is abducted.

Separation of the Epiphysis—**Occurrence**—This is a not unusual injury of late childhood and early youth It is commonly due to a fall on the arm

Displacement.—This depends largely on the fracturing force The shaft may be displaced upward and outward or may be tilted on the head fragment to form an angulation opening either medially or laterally There is almost invariably a fragment of diaphysis remaining on the epiphyseal fragment.

Diagnosis—The usual signs of fracture at the upper extremity of the humerus in a child or adolescent suggest an epiphyseal injury which may be confirmed by x-ray examination If the signs are definite but the x ray evidence is inconclusive

or negative, it may be assumed that a fracture has occurred at the epiphyseal line without displacement of the fragments. Subsequent *x*-ray films may show a faint line of callus

Pathology —Frequently soft part damage is not a conspicuous feature though it may be extensive in cases where the displacement of the fragments is great. Nerve injury is uncommon.

Treatment.—Because the injury has taken place through a region of growth accurate reduction with a minimum of trauma is desirable

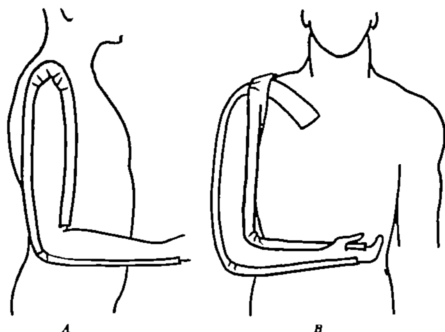


Fig 38.

Where no displacement has occurred *i e* when the diagnosis is clinical and not roentgenographic, a sling and swathe are all that are needed With a slight displacement easily reduced and held anterior and posterior molded plaster splints over the shoulder and down the arm or a modified sugar tongs splint will prove satisfactory (Fig 30) If

there is gross displacement it is frequently difficult or impossible to maintain the reduction because of the smooth epiphyseal cartilage at the bone ends Traction suspension may be required and in some instances operation is necessary to obtain and hold the accurate anatomical position essential

Time of Immobilization.—Healing is fairly rapid Two to three weeks' total protection is usually sufficient in simple cases four to six weeks for the more severe types.

Prognosis.—As in all cases of epiphyseal injury the prognosis should be guarded as to growth disturbance. Most cases will have a complete return of function in from four to six weeks but gradual cessation or diminution of growth may occur after several months.

Summary —

Accurate reduction advisable

Rapid return of function usual, but late growth disturbances possible

Fractures of the Greater Tuberosity —**Occurrence** —This injury is frequently associated with subcoracoid dislocations of the shoulder but may occur alone It is caused by muscle pull or by direct violence.

Displacement.—If the fragment is torn completely free from its attachment to the humerus, the muscles attached to it (supraspinatus infraspinatus and teres minor) will displace it upward and backward Usually, however, the fragment is only slightly lifted from its bed because its periosteal attachment to the shaft remains intact. If the injury is one of direct violence the tuberosity is depressed rather than pulled off

Diagnosis.—Acute local tenderness over the outer aspect of the shoulder with pain on attempted abduction and external rotation following an injury to the shoulder is suggestive of fracture X-ray films of the head of the humerus in internal and external rotation will differentiate between a fracture and a tear of the soft parts.

Pathology—Hemorrhage into the subdeltoid bursa and the surrounding muscles and tearing of the bursal floor may result from a pulling off of the tuberosity

Treatment.—Care of the soft part damage should be the chief consideration

If there is little or no displacement early active motion should be instituted This is obtained most easily in the first few days by suspension of the extremity so that the weight of the arm is supported Heat and gentle massage should be prescribed from the beginning If the fragment is greatly displaced operative replacement with rigid fixation should be considered in order that active motion can be started within a few days If this is impossible the arm should be held in abduction and external rotation in some form of suspension apparatus or aëroplane splint.

Time of Immobilization.—In simple cases a sling is usually necessary for about two weeks. If an aëroplane splint has been used it should be maintained for about three weeks.

Prognosis.—Painful and limited abduction and external rotation may persist for a long time but in most cases a useful shoulder will be obtained in from three to four months

Summary—

Usually associated with dislocation of humeral head
Fragment displaced up and back by muscles if periosteum is torn
Soft part pathology important consideration in treatment if fragment is not displaced

Fractures of the Lesser Tuberosity—These are rare injuries and are due in most instances to a sudden pull of the subscapularis muscle The diagnosis is suggested by localized tenderness over the lesser tuberosity and pain on adduction and internal rotation of the arm and is confirmed by *x* ray plates. The position of immobilization is that of adduction and internal rotation easily obtained by sling and swathe. Motion within pain limits heat and massage should be started from the first day

DISLOCATIONS OF THE UPPER EXTREMITY OF THE HUMERUS

Anterior or Subcoracoid.—Occurrence—The shoulder is more subject to dislocation than any other joint in the body The injury occurs preponderantly in young men engaged in strenuous activities but may occur at any age though rarely seen in childhood It is caused usually by a fall or blow on the abducted and internally rotated arm

Displacement.—The head of the humerus is forced out of the antero-inferior part of the capsule and slips forward and upward under the coracoid as the arm drops to the side and the muscles of the shoulder girdle contract

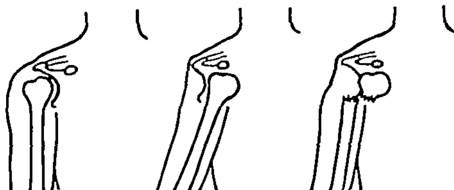


Fig 37

Diagnosis.—The appearance of a patient with a typical early subcoracoid dislocation is characteristic. The deltoid curve is flattened the axis of the humerus slants toward the base of the patient s neck instead of toward the acromion process and there is a prominence instead of a depression visible under the coracoid (Fig 37) The patient is unable to place the hand of the injured extremity on the opposite shoulder while the elbow is held against the chest (Duga s sign) Gentle palpation reveals the absence of the humeral head in the glenoid and its presence under the coracoid

The head and shaft of the humerus rotate together when the elbow is moved slightly if there is no complicating fracture (Fig 37) *X* ray films, while not essential for the diagnosis, should always be taken to rule out a coëxisting fracture.

Pathology —The capsule of the shoulder joint is thinnest at the antero-inferior aspect where the subscapularis bursa communicates with the joint. This is the usual site for

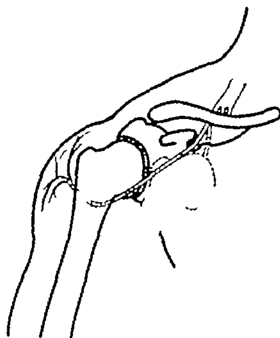


FIG. 38.—Axillary nerve. Showing probability of injury in classical dislocation of shoulder

emergence of the humeral head with tearing of the capsule The *axillary (circumflex) nerve is frequently damaged in the* original injury with resulting weakness of the deltoid and anesthesia or hypesthesia over the area of its cutaneous distribution (Fig 38) The infraclavicular portion of the brachial plexus lies in close proximity to the dislocated head and may be injured in the original trauma but much more frequently in forcible attempts at reduction.

Treatment.—The essentials of therapy consist of immediate reduction followed by as rapid a restoration to complete function as is consistent with the prevention of a recurrence of the dislocation

Reduction may be done without the use of general anesthesia if the patient is seen soon after the injury or if the dislocation is recurrent Usually however, an anesthetic is advisable in order to produce adequate muscular relaxation thereby lessening the force required for the manipulation All motions to accomplish the reduction should be smooth slow and steady Rough and jerky movements are unnecessary and cause damage Steady traction for five minutes or more in the direction of the axis of the arm will reduce most early dislocations without trouble Countertraction may be obtained by a swathe tied around the chest over the uninjured shoulder and fastened to some fixed object or held by an assistant. The "heel-in-the-axilla' method should never be used as there is grave danger of injuring the brachial plexus If reduction cannot be accomplished by traction alone the Kocher maneuvers should be tried They consist of (*A*) external rotation of the arm with the elbow flexed to 90 degrees (Fig 39) (*B*) adduction the elbow is moved across the chest (Fig 40) (*C*) internal rotation, the hand drops to the opposite shoulder (Fig 41) Steady traction should accompany all the motions and they should be done slowly and smoothly

If the dislocation has existed for some days reduction may be impossible by the above methods without the use of undue force In such cases skin traction of 10 to 15 pounds applied over a period of hours is valuable to relax the muscles and slowly stretch the soft parts.

In the early cases after reduction a sling and swathe should be used for two or three days followed by a sling for another week or ten days. Heat massage and active motion within pain limits should be instituted from the beginning The patient should be warned against abduction beyond 90

Fig 39

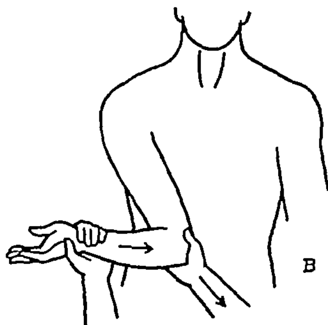


Fig. 40.

degrees for from four to six weeks because of the danger of recurrence If there is evidence of axillary nerve damage or much soft part trauma the patient should be admitted to a hospital for suspension of the arm at 70 degrees abduction to allow intensive physical therapy and to relax the strain on the deltoid



FIG. 41

Time of Immobilization.—Sling protection for two or three weeks is usually adequate with abduction limited for four or six weeks

Prognosis.—Full functional return in from six to eight weeks is the usual result in early cases Recurrences are not infrequent however and the patient should be warned against them

Recurrent dislocations are best treated for permanent cure by operative means.

Summary—

Most frequent of all dislocations.

Deformity striking flattening of shoulder bulge under coracoid, axis of arm through base of neck

Axillary nerve injury common
Reduction by steady traction usually easy
Sling and swathe for a few days.
Recurrence not uncommon

Inferior or Subglenoid.—In these cases the head of the humerus remains where it has emerged from the joint and does not slip up under the coracoid The arm appears longer than the other side but in all other respects appearance and treatment are similar to those of the subcoracoid type

Posterior—These dislocations are rare The diagnosis is usually obvious because the humeral head can be palpated behind the scapula. Reduction is accomplished by steady traction in the axis of the humerus.

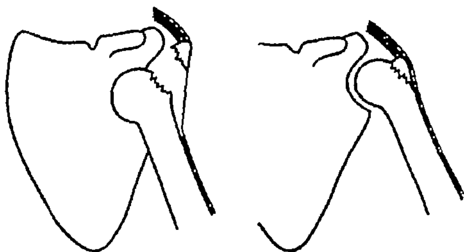


Fig. 42.

Complications of Shoulder Dislocations.—Fracture of the Greater Tuberosity—This is of frequent occurrence and offers no contraindication to the immediate reduction of the dislocation. Usually the fragment slips back into place without difficulty (Fig 42) Suspension of the arm in 70 degrees abduction for several days with intensive physical therapy will materially shorten the period of convalescence

Fracture of the Glenoid —Occasionally a fragment is broken from the rim of the glenoid and may make a reduction impossible to maintain without operative interference

Fracture of the Anatomical or of the Surgical Neck.—These cases form one of the most difficult problems in all fracture surgery The diagnosis is suggested by the signs of a subcoracoid dislocation modified by shortening of the arm, by a failure of the head to rotate with the shaft, and occasionally by crepitus. *X*-ray pictures confirm the diagnosis Occasionally manipulative reduction can be accomplished in an early case if great care is used to prevent further damage Frequently however operation is necessary If there is sufficient soft part attachment to the head fragment to provide adequate blood supply it should be replaced if possible If the fracture is high *i e* through the anatomical neck, it is wiser to remove the fragment because of the danger of late changes in the head with increasing disability

Displacement of the Long Head of the Biceps.—Rarely the long head of the biceps is torn out of the bicipital groove and becomes displaced behind the humeral head Reduction can be effected but cannot be maintained, as any action of the biceps flips the head out of the joint. Operative interference is necessary in such cases

CHAPTER VIII

FRACTURES OF THE SHAFT OF THE HUMERUS

Occurrence —These injuries occur usually in active adult life They are caused for the most part by severe violence either direct or indirect. Rarely a fracture may be caused by muscle action, especially in the upper third when the bone is weakened by a solitary cyst.

Displacement.—Occasionally particularly in children there may be no displacement. Usually, however, if the fracture is complete the fragments tend to override because of the strength of the muscle pull If the fracture line is above the deltoid insertion there is a tendency for the lower fragment to be displaced outward For the most part the displacement is determined by the fracturing force. Comminution is a frequent finding

Diagnosis.—If there is displacement the diagnosis can be made at a glance for the deformity is obvious. In cases with no deformity *x*-ray films are essential to differentiate between a fracture and a soft part injury

Pathology —The radial (musculospiral) nerve winds around the shaft of the humerus close to the bone between the internal and external heads of the triceps. In fractures of the middle third of the shaft the nerve is frequently injured at the time of the original trauma (Fig 43) during manipulative reduction or later by pressure of the callus. Interposition of soft parts between the bone ends is a not infrequent finding

Delayed and non-union are relatively frequent in fractures of the humeral shaft and are unfortunate complications The difficulty of adequate immobilization is thought to be a contributing factor

Treatment.—Rigid fixation *for a period of time sufficient* to ensure union is of primary importance after a satisfactory position has been obtained

When there is no displacement anterior and posterior molded splints or sugar tongs splints (see Fig 36) are adequate An axillary pad or triangle should be worn with them to prevent adduction of the elbow with resulting angulation at the fracture site These splints should be worn for from four to six weeks

If the fracture is transverse it is sometimes possible to obtain good position by a closed manipulation under an

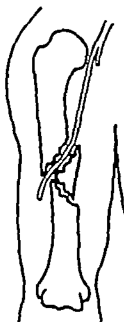


Fig. 43.

anesthetic. If there is no tendency for the fragments to slip once reduction has been accomplished the case can then be treated with the splints mentioned in the foregoing paragraph Care should be taken to prevent the internal rotation of the lower fragment produced by allowing the forearm to lie across the chest.

The usual fracture of the humeral shaft cannot, however be held in good position without some form of traction or

some type of internal fixation Skin traction by means of adhesive strips or by Magnuson felt yokes[1] is adequate in many cases as 15 pounds is usually the maximum weight required. A modified Russel traction has been described[2] for these cases but great care is required to avoid an overpull Skeletal traction by means of a Kirschner wire through the lower end of the humerus or through the olecranon is of great value, especially if there are skin lesions complicating the fracture If traction is used in any form a small plaster-of Paris cuff or coaptation splints around the fragments will help to lessen the motion that occurs at the fracture site when the patient moves around in bed Traction should not be made through an extended elbow for any length of time because of the resulting disability in the elbow joint. The Thomas splint should be used only for emergency treatment and for transportation

Various ambulatory traction devices have been described of which the best known is the Jones splint. This may become unbearably uncomfortable for the patient if it is firmly applied

Because of the great danger of non-union in these cases, all that are treated by any form of traction should be carefully watched for overpull Normal axes and bone contact are more important for a good functional result than full length with loss of bone contact.

When there is interposition of soft parts, evidence of nerve injury or inability to obtain satisfactory position by any other means operative interference is indicated, preferably with rigid internal fixation. Under ideal conditions operation may be considered as a primary procedure in any case with gross displacement.

Active motion must be limited until union is assured

[1] Magnuson, Paul B. Fractures, Philadelphia, J B Lippincott Company Fig. 79, p. 112, 1933.
[2] Blum, Lester Double Pulley Traction in Fractures of the Shaft of the Humerus Report of Case, Jour Am Med. Assn., 101, 1953, 1933.

Time of Immobilization.—When there has been no displacement, splints should be left on for from four to six weeks, followed by a sling for two weeks Fractures that have been treated by closed reduction and splints need immobilization for from six to eight weeks at least. Oblique fractures and those requiring traction should be kept in their apparatus until there is no tendency for the fragments to slip Coaptation splints can then be used until union is firm, usually for from eight to ten weeks from the time of injury

Prognosis.—Functional return of the extremity is good in cases without serious nerve injury or without non-union In favorable cases the patient should have a useful arm in three or four months after injury

Summary —

- Injuries caused by considerable violence, frequently with gross deformity
- Radial nerve injury frequent in fractures at middle third of shaft.
- Traction (skin or skeletal) or open reduction necessary in cases with displacement of fragments.
- Delayed or non union not uncommon

CHAPTER IX.

INJURIES AT THE ELBOW-JOINT

FRACTURES OF THE LOWER EXTREMITY OF THE HUMERUS

Supracondylar or Dicondylar Fractures —Occurrence.—These are common accidents of childhood They are caused by a fall on the hand or forearm, very rarely by a fall or blow on the back of the elbow

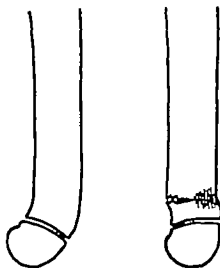


FIG. 44

Displacement.—The lower end of the humerus curves forward so that from a lateral view a line through the capitellum forms an angle with the axis of the shaft. The direction of the fracturing force is usually such that the distal fragment is displaced backward There may be only angulation *i. e* the capitellum may lie in line with the axis of the shaft (Fig 44) or there may be complete separation with over

riding (Fig 45) Lateral or medial shift of the distal fragment may occur and frequently there is a rotary displacement of the lower end of the humerus on the shaft.

Anterior displacement is a rare occurrence and is due to a force directed from behind

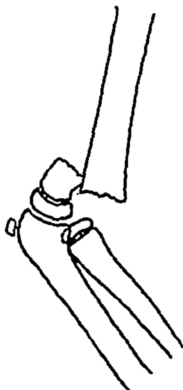


Fig 45.

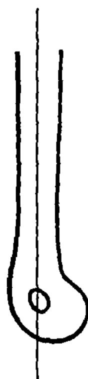


Fig. 46.

Diagnosis.—There are certain landmarks around the elbow-joint which are important aids in diagnosis. The two epicondyles can be easily palpated even when there is considerable swelling Normally they lie in line with the shaft of the humerus (Fig 46) The olecranon process can also be palpated With the elbow flexed the tip of the olecranon lies equidistant between the two epicondyles and the three points form an isosceles triangle (Figs 47 and 48) With the elbow

extended the tip of the olecranon lies on the line joining the epicondyles (Figs. 49 and 50) When the elbow is extended

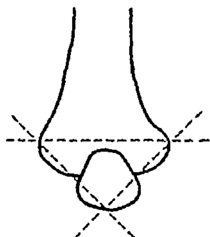


FIG. 47

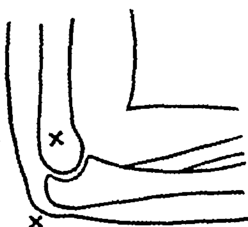


FIG. 48.

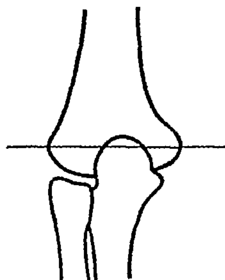


FIG. 49.

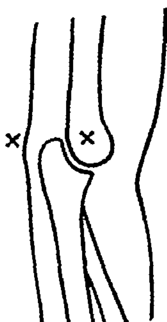


FIG. 50.

and the forearm supinated the forearm normally swings slightly outward so that its axis forms an angle with a continuation of the axis of the arm of from 5 to 20 degrees, the "carrying angle" When the elbow is completely flexed and the forearm supinated the hand drops to the acromion process

In a supracondylar fracture with gross displacement, backward displacement of the elbow is visible. On palpation it is found that the relationship between the epicondyles and the olecranon is normal but that the epicondyles lie posterior to the axis of the humerus (Fig 51) There may be measurable shortening of the arm

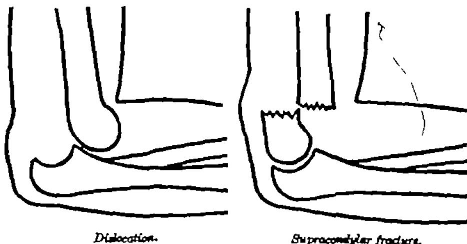


Fig 51

If there is little or no displacement linear tenderness across the lower end of the humerus both anteriorly and posteriorly and indirect tenderness elicited by gentle pressure on the olecranon with the elbow flexed suggest the diagnosis *X* ray plates are always necessary

Pathology —Because of the tight fascia stretched across the front of the elbow (lacertus fibrosus or bicipital fascia) backward displacement of the distal fragment produces pressure on the brachial artery and may completely occlude it

(Fig 45) Hemorrhage and edema beneath the fascia hinder the venous and lymphatic drainage and an ischemic paralysis (Volkmann's) may be the result. This can also be caused by constricting bandages and is one of the most tragic accidents in traumatic surgery because it is almost always preventable Occasionally, but less frequently than the circulatory damage, one of the nerves may be injured in the original trauma.

Treatment.—Early accurate reduction is essential in these cases. As the majority of patients are children the functional return is satisfactory if the deformity is corrected

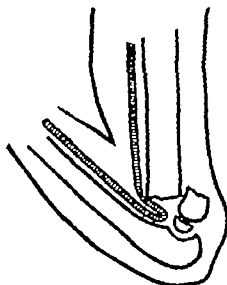


Fig 52.—Possible effect of flexion on the brachial artery

Palpation of the radial pulse and examination of the fingers for color, temperature sensation and motion should always be part of the original examination If the radial pulse is not palpable or is very weak, speed of reduction is even more important than in the uncomplicated case.

In many cases reduction by manipulation under an anesthetic can be done satisfactorily Traction on the distal fragment must be maintained throughout the maneuver to

release the impinging bone ends. Care must be taken to correct rotation of the fragment as well as posterior and lateral or medial displacements. Flexion of the elbow is a position of maintenance, not of reduction (Fig 52) and should not be done until the fragments are in line When a satisfactory position has been obtained the elbow should be flexed with the radial pulse under palpation during the procedure Should the pulse grow weak or disappear, the flexion should be reduced until the pulse is again maximum The position can be held by a posterior molded splint from shoulder to knuckles. Circular plaster should never be used Figure-of-eight adhesive strips are unsatisfactory as swelling occurs between the strips and internal rotation of the lower fragment may take place when the forearm swings across the chest. The forearm should be in supination or pronation whichever holds the position better Usually supination is satisfactory Every effort should be made to avoid any constricting plaster or bandage in the antecubital fossa

Following reduction and splinting the arm should be elevated and the patient under close observation for at least twenty four hours. Pulse color and temperature of the fingers should be frequently observed and the bandage cut down at the slightest suggestion of diminished circulation. Volkmann s paralysis can occur in a few hours.

If conditions are satisfactory the splint should be left in place for about two weeks and then replaced by a sling for another week. Physical therapy is not needed and may be definitely harmful

If reduction cannot be obtained by manipulation or if it cannot be maintained at the degree of flexion necessary to get the maximal radial pulse traction by means of a Kirschner wire through the base of the olecranon is extremely satisfactory The arm should be suspended over the bed so that circulatory drainage is obtained (Fig 53) Anatomical reposition can be achieved in a few hours by adjusting the line of pull In these cases traction should be maintained for from

eight to ten days and followed by a posterior molded splint holding the elbow in flexion for another week.

If the radial pulse is not palpable on the first examination and does not return within one-half hour of traction and suspension operative slitting of the fascia of elbow and forearm should be considered There is no excuse for waiting "until the swelling goes down,' for the swelling is largely due to the deformity The quickest way to reduce the swelling is to reduce the fracture

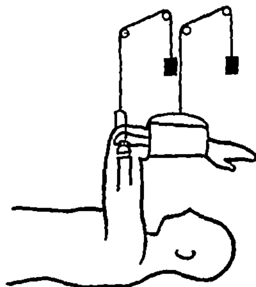


Fig 53.

Operative reductions should be done in these cases only as a last resort because the results are sometimes disappointing

Complete functional return is likely to be slow and should not be rushed by any forceful means. Manipulations to increase elbow motion are dangerous and unnecessary Use of the extremity in normal activities is usually all that is needed to restore full range of motion If the child is timid and continues to protect the injured elbow confinement of the uninjured arm in a sling beneath the shirt is a simple and valuable expedient.

Time of Immobilization.—Simple fractures should be splinted for two weeks followed by a sling for one week More complicated cases should have splint protection for at least three weeks

Prognosis.—If a satisfactory reduction is obtained the result should be good both anatomically and functionally in from four to six months Occasionally growth disturbances and inaccurate reduction result in unsightly elbows, most frequently in a reversed carrying angle or "gun stock deformity

Complications of Supracondylar Fractures.—Volkmann's ischemic paralysis caused by interference with the circulation by pressure either from within or from without, may occur within a few hours after injury and cause permanent damage to forearm and hand Massive replacement of muscle fibers by fibrous tissue makes late correction difficult and in some cases impossible

Myositis ossificans the formation of bone in muscle, may occur in the fibers of the brachialis Forced passive motions and deep massage seem to be favorable to its formation The bony mass increases in size for from six to nine months after onset remains stationary about three months, and then regresses Normal use of the extremity is the only treatment. Operative removal should never be attempted during the period of growth of the mass for recurrence is almost inevitable Frequently the osseous tissue will completely disappear spontaneously If not it can be removed when it has reached its minimum size

Summary—

- A common injury of childhood
- Backward and rotary displacement of distal fragment usual.
- Immediate accurate reduction and immobilization in flexion satisfactory in most cases.
- Wire traction through the upper extremity of ulna valuable in difficult cases

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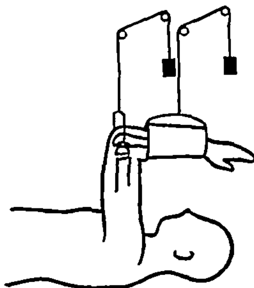


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because of the shape of the fragments Early active motion must be stressed

Time of Immobilization.—This varies with the extent of separation or displacement of the fragments Healing in most instances should be solid enough in from six to eight weeks to allow the patient to go without any protection

Prognosis.—These are serious injuries and seldom result in a perfect extremity Careful treatment should give a useful arm but almost always extension remains limited

Summary —

Serious injuries in adults

Wire traction through olecranon useful

Operative fixation necessary in certain cases

Function more important than anatomical restoration

Prolonged immobilization to be avoided because of danger of a stiff joint.

Fractures of the Condyles.—**External Condyle** —**Occurrence** —This is not an infrequent accident, usually of childhood It is caused by a force directed upward against the outer side of the articular surface of the humerus or by a hyper adduction of the forearm

Displacement. —The fracture line runs upward from the joint surface just medial to the capitellum including the capitellar epiphysis and slants outward to the external supracondylar ridge.

Any degree of separation may occur from a slight crack to a complete rotation of 180 degrees. The pull of the extensor muscles of the forearm tends to pivot the fragment laterally so that in extreme cases the fracture surface may face outward (Fig 54)

Diagnosis. —Tenderness and swelling localized to the outer side of the elbow with or without palpable displacement of the lateral condyle suggest this injury *X*-ray examination is necessary to determine the amount of displacement.

Pathology —The extensor group of muscles attaches to the external supracondylar ridge and some part of the attach

Circulatory damage a danger which must be anticipated and prevented

Anatomical restoration important to prevent unsightly deformity

T or Y Fractures.—Occurrence.—These fractures are most frequently found in adults and are caused by a blow or fall on the flexed elbow or by a fall on the hand

Displacement—The condyles are often spread apart with the ulna jammed up between them or the upper humeral fragment pushed down.

Diagnosis.—In severe cases broadening of the lower end of the humerus is apparent. There may be a changed relationship between the epicondyles and the olecranon Tenderness on lateral pressure over the epicondyles is present and occasionally the condyles can be felt to move toward each other on such pressure Shortening of the arm may be measurable. Roentgenographs are essential for details of the injury

Pathology—As in most elbow injuries there is marked swelling Rarely one or more of the nerves may be injured in the original trauma.

Treatment.—In adults functional return is more important than anatomical restoration A perfectly reduced fracture immobilized over a period of weeks may result in a stiff elbow Therefore while closed reduction and immobilization may be possible some form of treatment to allow early return of motion is preferable Traction and suspension by a Magnuson felt or by Kirschner wire through the olecranon with physical therapy in the form of heat and massage may be of value in some cases. Traction should be maintained for from three to five weeks and then the patient allowed up with the elbow protected by a posterior molded splint which should be removed daily for active exercise All protection should be off in eight weeks. In other cases operative reduction with some form of internal fixation by means of nails screws or pegs may be necessary, though frequently mechanically difficult

by muscle pull It may be associated with dislocation at the elbow joint.

Displacement.—The fragment is pulled downward by the flexor muscles. Rarely, usually associated with dislocation of the forearm bones, the fragment is pulled into the joint and lies between ulna and trochlea (Fig 55)

Diagnosis.—Localized tenderness and swelling over the medial aspect of the elbow with prominence of the internal epicondyle are suggestive *X*-ray films are

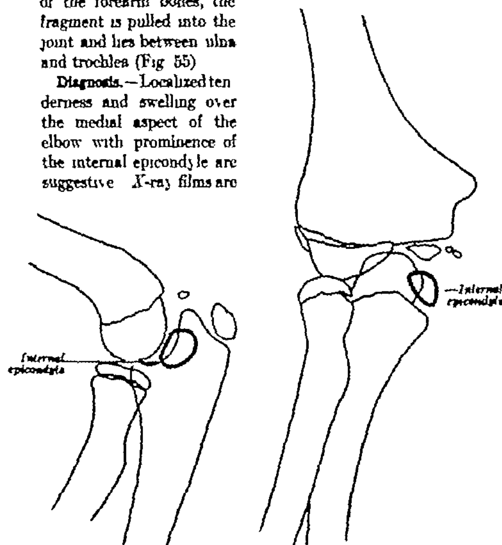


FIG. 55.

essential The characteristic kidney bean or semi-oval shape of the epicondyle distinguishes it from the semicircular or

ment is frequently torn off with the fragment. Nerve injuries are rare

Treatment.—Accurate replacement of the fragment is necessary to prevent unsightly deformities. Where the displacement is negligible a posterior molded splint holding the elbow in moderate flexion, and maintained for from two to three weeks, is all that is required Where there is marked separation and rotation of the fragment immediate reduction by manipulation under an anesthetic may be tried, but is rarely successful Open operation with replacement and fixation of the fragment is usually necessary Removal of the fragment should be done only in late cases where the chance of obtaining an accurate reposition is negligible.

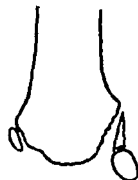


Fig. 54.

Time of Immobilization.—A splint for about three weeks is usually advisable followed by a sling for another week.

Prognosis.—Functional return is good in three to four months as a rule but a prominence of the external condyle to greater or lesser degree is a frequent result. If an increased carrying angle results due to an upward slipping of the condyle, there may be late ulnar nerve symptoms due to stretching

Summary —

Rotary displacement due to muscle pull.

Operative fixation frequently necessary

Ulnar nerve symptoms a possible late complication

Internal Condyle.—These are rare injuries, usually occurring in adults and requiring operative replacement and fixation if the fragment is markedly displaced

Internal Epicondyle.—**Occurrence.**—A common injury in childhood this fracture is caused by a forcible abduction of the forearm, tearing off the fragment (usually the epiphysis)

by muscle pull It may be associated with dislocation at the elbow-joint

Displacement.—The fragment is pulled downward by the flexor muscles Rarely, usually associated with dislocation of the forearm bones the fragment is pulled into the joint and lies between ulna and trochlea (Fig 55)

Diagnosis.—Localized tenderness and swelling over the medial aspect of the elbow with *prominence of the internal epicondyle* are suggestive X-ray films are

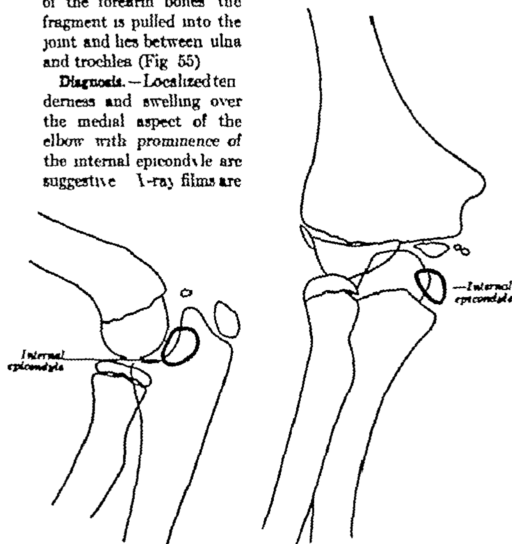


FIG 55.

essential The characteristic kidney bean or semi-oval shape of the epicondyle distinguishes it from the semicircular or

pie-shaped fragments of the radial head for which it might be mistaken (Fig 55)

Pathology—There may be very little swelling with this injury unless there has been considerable soft part damage Occasionally the ulnar nerve is injured.

Treatment.—Gross separation should be corrected but excellent functional results are obtained even if moderate deformity persists. If the fragment is outside the joint, manipulation by direct pressure followed by a posterior plaster splint with the elbow in flexion is frequently satisfactory The splint should be kept on for from two to three weeks

If the fragment lies in the joint, operative interference is usually necessary The epiphysis should not be removed but sutured into place Treatment should be continued as in the uncomplicated cases

Time of Immobilization.—Splints should be maintained for two or three weeks and a sling for another week.

Prognosis.—Return of function is usually excellent even with a fibrous union of the fragments. Full extension may be slow in returning as is frequently the case in all elbow injuries.

Summary—

- Displacement downward due to muscle pull occasionally in the joint after dislocation of both bones
- Closed reduction in simple cases.
- Operative reduction when in the joint.
- Ulnar nerve injury a possible complication

Separation of the Epiphysis Without Displacement.—**Occurrence**—These injuries are quite common and are frequently diagnosed as sprains or bruises They are usually due to a fall on the extended hand

Diagnosis.—Tenderness at the lower end of the humerus which extends across the bone both anteriorly and posteriorly and is accompanied by swelling suggests a possible fracture With definite signs of fracture but a negative *x* ray

plate, the possibility of a break across the epiphyseal cartilage must be considered

Pathology.—There is always moderate swelling but gross circulatory damage does not occur Nerve injuries also are not found X-ray films taken ten days to two weeks after the injury frequently show a faint line of callus running up the humeral shaft.

Treatment.—These cases should be treated like supracondylar fractures without displacement, *i e* with posterior molded splint for two weeks. They may be slow in regaining complete extension but attempts to hurry the return of function by physical therapy should not be made.

Time of Immobilization.—Splint protection is necessary for about two weeks

Prognosis.—Full functional return is the rule but may be slower than the parents anticipate Rarely growth disturbances may occur

Summary —

Frequent injuries showing signs and symptoms of fracture but no x-ray evidence.

Splint protection for two weeks.

Functional return complete but growth disturbance a possibility

FRACTURES OF THE UPPER EXTREMITY OF THE RADIUS

Fractures of the Radial Head.—**Occurrence**.—These injuries are fairly frequent and are likely to be overlooked They are caused by a fall on the hand or forearm and may be associated with discoloration at the elbow

Displacement.—The fragments may be completely separated from the head or merely depressed The position depends on the fracturing force Frequently the fracture is represented by a crack through the articular surface with no displacement (Fig 56)

Diagnosis.—The presence of a distended joint capsule associated with limitation of motion, especially pronation and supination and tenderness over the radial head following a fall, suggests a fracture A characteristic symptom is that of gradually increasing pain two or three hours after the injury, caused by the increasing pressure in the joint from the hemarthrosis *X* ray pictures are not always conclusive as they may not show a small crack. The diagnosis should be made on clinical evidence

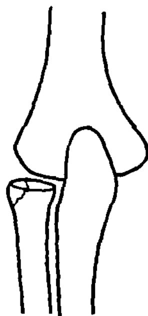


Fig 56.

Pathology—If there is no displacement, blood in the joint is the principal evidence of damage. If the fragment is displaced anteriorly, especially if the capsule is torn, there is usually considerable injury to the soft parts in the front of the elbow In such cases excessive bone production or overgrowth is a danger Because of the tearing of the capsule the blood escapes into the tissues and there will not be a hemarthrosis. Rarely there is damage to the radial nerve

Treatment.—1 *Fractures Without Displacement.*—If there is sufficient fluid in the joint to cause limitation of motion and pain the joint should be aspirated A posterior molded splint for the first two or three days tends to prevent further bleeding into the joint and provides rest and protection After that a sling for a week or ten days is all that is needed for immobilization Active motion within pain limits should be started after twenty four hours.

2. *Fractures With Displacement*—If there is gross displacement of a considerable portion of the head the best procedure is operative removal, usually of the entire head

There are some who advocate removing the fragment only when it is small Closed reduction of the fracture is almost invariably impossible in adults Operation should be performed within the first few days following injury or several months later, not in the active bone-forming period If there is anterior displacement of the fragments with injury to the soft parts in the antecubital fossa, the sooner the operation can be done the less danger there is of bony overgrowth Following operation active motion should be started as soon as possible

Time of Immobilization.—A splint is necessary for only two or three days in most cases. A sling may be used for from one to two weeks.

Prognosis.—Return of full extension of the elbow may be delayed for months even in those cases where there is no displacement of the fragment However full return of motion may be expected in from six months to a year in the usual uncomplicated fracture In operative cases if the operation is done early satisfactory return of painless motion may be expected within a year In certain injuries however, there is so much soft part damage especially in the anterior portion of the elbow that bone production may occur following operation resulting in some instances in synostosis between the radius and the ulna and causing marked limitation of function The prognosis in operative cases should therefore be guarded

Summary.—

Hemarthrosis limitation of motion, and radial head tenderness characteristic signs.

Aspiration and early active motion in simple cases

Operative removal of head in cases with displacement.

Fractures in the Neck of the Radius.—These are not as frequent as fractures of the head In cases with gross displacement operative removal of the head is necessary In children however in whom these cases are frequently seen reduction should be done because the removal of the head

fragment in the growing child will lead to a deformed joint Reduction can occasionally be done by closed manipulation but may require open operation. Hemarthrosis will not occur if the fracture line does not run into the joint.

Separations of the Epiphysis —These are relatively infrequent. They must be reduced by closed or open methods and then immobilized by posterior molded splint for from two to three weeks The prognosis is good except for the danger of growth disturbance

FRACTURES OF THE UPPER EXTREMITY OF THE ULNA.

Fractures of the Olecranon Process.—Occurrence —These are fairly common fractures in adults, not so frequent in children They may be produced either by indirect violence or by a direct blow

Displacement.—The proximal fragment is most frequently pulled upward by the triceps. Fractures caused by direct violence are usually stellate in type without gross displacement.

Diagnosis.—Because of the subcutaneous position of the olecranon diagnosis of a fracture with displacement is easy The displaced fragment is palpable and active extension of the forearm on the arm is lost. Swelling directly over the olecranon with no palpable bony deformity but tenderness both direct and indirect, suggest a fracture without displacement.

Pathology —In fractures caused by direct violence there is usually considerable swelling because of the damage to the overlying soft parts The aponeurosis of the triceps however is intact. If there is any separation of the fragment the lateral expansion of the triceps must be torn There may be injury to the ulnar nerve

Treatment.—Where there is no displacement immobilization with a posterior molded splint, with the elbow at right

angles, is all that is necessary Guided active motion may be started within a few days The splint should be maintained for about three weeks. Where there is separation of the fragments indicative of tearing of the expansion of the triceps the most satisfactory treatment is open reduction with fixation of the fragments Active motion should be started as soon after operation as is possible certainly by the end of three weeks If for some reason open reduction is contraindicated the upper extremity should be immobilized for from three to four weeks by anterior and posterior molded splints from shoulder to hand with the elbow in complete extension.

Time of Immobilization.—Splints in the undisplaced fracture should usually be maintained for about two weeks. Three to four weeks of immobilization is necessary when the fragments have been displaced if open reduction with internal fixation has not been carried out.

Prognosis —Full functional return should be expected in about three months in the undisplaced and in four or five months in the operative cases Bony union is the usual result but a dense fibrous union will give satisfactory function

Summary —

Tearing of soft parts important feature in fracture with separation

Treatment for undisplaced fractures splint and guided active motion

Treatment for displaced fractures, operative fixation

Fractures of the Coronoid Process —Occurrence —These are relatively rare injuries occasionally associated with posterior dislocations of the elbow They are usually caused by a fall on the hand or forearm with the direction of force such that the coronoid is driven against the trochlea.

Displacement.—If the fragment consists of the tip of the bone it may lie free in the joint. If however the fracture line is more distal it may include fibers of the attachment of the brachialis and the fragment will then be pulled upward

Diagnosis —A painful elbow with tenderness in the antecubital fossa is suggestive of this injury Diagnosis is usually made by x ray examination

Pathology —As has been said this injury occasionally accompanies posterior dislocation at the elbow and may be associated with considerable soft part damage and tearing of the joint capsule On the other hand fracture through the tip may be associated with hemarthrosis only Where there has been tearing of the brachialis there may be an overproduction of bone in this muscle

Treatment.—If the fragment is small immobilization of the elbow in a semiflexed position for from two to three weeks is all that is necessary If the fragment is large it may be forced into place by a position of acute flexion which should be maintained about three weeks. Occasionally a small fragment will not unite and may have to be removed from the joint.

Time of Immobilization.—This is usually between two and three weeks.

Prognosis.—Functional return may be complete in three or four months. On the other hand there may be persistent limitation of motion which will require removal of the frag ment. In a few cases the fragment is reattached with increase in growth, giving a mechanical block to flexion

Summary —

Occasionally seen with posterior dislocations
Immobilization in flexion for from two to three weeks.

DISLOCATIONS AT THE ELBOW

Both Bones Backward.—**Occurrence** —This is second only to dislocations of the shoulder in frequency of occurrence In children it is the most frequent dislocation It is usually caused by a fall on the outstretched hand with the elbow in extension

Displacement.—The forearm is forced backward by the mechanism of the injury and held in that position by the pull of the triceps The coronoid usually lies behind the humerus in the olecranon fossa

Diagnosis.—There is gross visible deformity at the elbow with the olecranon projecting posteriorly to the axis of the humerus. The relationship of the epicondyles to the olecranon is altered but that of the epicondyles to the humeral axis is unchanged thus differentiating a dislocation from a supracondylar fracture (Fig 51) The diagnosis should be confirmed by *x*-ray films because the presence of an associated fracture may not be recognized by clinical examination

Pathology—If the forearm is forced backward on the arm the anterior portion of the capsule must tear There are also torn fibers of the brachialis anticus and possibly damage to the radial and median nerves as they are stretched over the anterior aspect of the lower end of the humerus Nerve and vessel injury are however rare Because of the tearing of the anterior structures of the elbow joint the danger of myositis ossificans following a posterior dislocation is a real one.

Treatment.—Reduction should be accomplished as soon as possible in order to minimize the soft part stretching A general anesthetic should be used for complete relaxation Reduction is accomplished either by hyperextension or by backward displacement of the forearm on the arm to release the coronoid from the dorsal aspect of the humerus accompanied by steady downward traction followed by flexion If the forearm cannot be completely flexed on the arm reduction has not been complete and a second attempt should be made A posterior molded splint with the elbow at right angles should be applied and maintained for three or four days for protection and rest of the soft parts. Immediate physical therapy in the form of heat and gentle massage is advisable Active motion within pain limits may be started within two or three days in the uncomplicated cases Exten-

Diagnosis.—A painful elbow with tenderness in the antecubital fossa is suggestive of this injury Diagnosis is usually made by *x*-ray examination

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Occasionally seen with posterior dislocations
Immobilization in flexion for from two to three weeks.

DISLOCATIONS AT THE ELBOW

Both Bones Backward—**Occurrence**—This is second only to dislocations of the shoulder in frequency of occurrence In children it is the most frequent dislocation It is usually caused by a fall on the outstretched hand with the elbow in *extension*

Forward Dislocation.—This rare injury can occur only with fracture of the olecranon Following reduction, repair of the olecranon and triceps expansion is of primary importance.

Dislocations of Head of the Radius.—Occurrence —These injuries are almost invariably associated with fracture of the upper third of the shaft of the ulna and should always be looked for in such fractures With the anterior angulation of the ulnar shaft the radius is forced forward either breaking through or pulling out of the orbicular ligament.

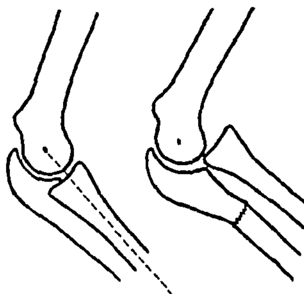


FIG 57

Displacement.—The radial head is forced forward as the ulna is broken and is pulled upward and held by the biceps

Diagnosis.—The radial head can usually be palpated anterior to its normal position In long-standing cases this is particularly marked when the forearm is extended on the arm In fresh injuries where the fracture of the ulna is obvious the examiner should always look for the anterior position of the radial head All the usual signs and symptoms of fracture are present X-ray examination will confirm the diagnosis if it is remembered that normally a line through the

sion of the forearm on the arm however should not be allowed for about three weeks because of the danger of redislocation.

The treatment outlined may have to be altered if there are associated fractures Occasionally in children the epiphysis of the internal epicondyle may be pulled off at the time of the dislocation and caught in the joint as the dislocation is reduced This complication should be recognized on post reduction x ray films. Operation and removal of the bone from the joint with reattachment to its normal place must be done. Fractures of the radial head frequently accompany a dislocation and may necessitate an early operation as already discussed

Time of Immobilization.—A splint is needed for physiological rest for three or four days and a sling to prevent extension should be maintained for about three weeks

Prognosis.—In almost every case of dislocation of the elbow follow-up x ray plates will show calcification in the collateral ligaments In most instances however the calcium deposit is not enough to interfere with function which should be complete in from four to six months Occasionally, however soft part damage is so great, especially in those cases associated with fractures that overproduction of bone results. In such cases the prognosis for full return of function should be guarded

Summary—

- Frequent injury with characteristic posterior deformity of elbow
- Treatment by manipulative reduction under anesthesia and splint protection for from three to four days.
- Soft part damage with late calcification and ossification in the tissues.

Lateral and Medial Dislocations.—These are variations of posterior dislocations and the pathology treatment and prognosis are similar

Operative repair of orbicular ligament as well as reduction of ulna usually necessary

Closed reduction occasionally possible

Subluxation of the Radial Head.—**Occurrence** —This injury is found only in young children and is caused by a sudden jerk on the wrist or forearm

Displacement.—It is supposed that the radial head is pulled slightly in the orbicular ligament, but neither clinically nor by x-ray can any displacement be made out.

Diagnosis.—Frequently the child is too young to explain his symptoms. Careful examination of the extremity, however, will elicit a sharp cry when the elbow is examined and pressure is made over the radial head Pronation and supination of the forearm are limited With the history that the child refuses to use the arm following a jerk or pull on the wrist and with no pathology found elsewhere the diagnosis is suggested X-ray examination is of negative value only in these cases, as it serves to rule out a fracture

Pathology —Very little if anything is known of the actual pathology of this lesion It is obvious by the symptomatology that some mechanical interference with rotation has occurred *i e* something has slipped out of place that can be replaced easily

Treatment.—Firm steady supination of the forearm while pressure is maintained over the radial head will under most circumstances relieve the condition immediately No anesthesia is necessary Frequently a click can be felt many times the condition is relieved spontaneously A sling as a protection for a few days is all that is necessary

Time of Immobilization.—No splint is necessary A sling may be used for a few days

Prognosis.—Complete return of function may be expected in twenty-four hours.

Summary —

Caused by a jerk on hand or forearm and evidenced by pain and limitation of rotation

Reduced spontaneously or by firm supination

long axis of the shaft of the radius will go through the capitellum (Fig 57)

Pathology—The head of the radius may tear through the fibers of the orbicular ligament or in some instances pull out beneath it, leaving the orbicular ligament more or less intact. If the bone has torn out it may be possible to replace the head through the gap from which it emerged Frequently however, the torn edges of the orbicular ligament fall back and lie between the radial head and the lesser sigmoid cavity In such instances of course closed reduction is impossible to maintain Nerve and blood vessel injuries are rare.

Treatment.—Closed reduction of the angulation of the ulna with the replacement of the radial head can be done in certain cases In the majority of instances however it is necessary to repair the orbicular ligament at the same time that an open reduction of the ulnar fracture is accomplished If an angular deformity of the ulna is allowed to persist, dislocation of the radius will recur Following reduction, either closed or open a posterior molded splint should be applied with the forearm at right angles to the arm. This should be maintained for about three weeks and followed by guided active motion

Time of Immobilization.—A posterior molded splint should be maintained for from three to five weeks or until there is x ray evidence of healing of the ulna.

Prognosis.—If the dislocation of the radial head is recognized early and reduced full functional return should be expected If the dislocation is unrecognized and allowed to persist, motions at the elbow joint will be limited In children this limitation of motion may not occur for several years after the injury until the lower end of the humerus has increased in size to such an extent that the radial head impinges upon the lateral condyle in flexion instead of slipping by it.

Summary—

Associated with anterior angulation or displacement of the upper ulnar shaft.

Operative repair of orbicular ligament as well as reduction of ulna usually necessary

Closed reduction occasionally possible

Subluxation of the Radial Head.—**Occurrence**—This injury is found only in young children and is caused by a sudden jerk on the wrist or forearm

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Summary—

Caused by a jerk on hand or forearm and evidenced by pain and limitation of rotation

Reduced spontaneously or by firm supination

CHAPTER X.

INJURIES TO THE FOREARM.

FRACTURES OF RADIUS AND ULNA.

Occurrence—These injuries are usually seen in children and in young adults but may occur at any age. They are caused by direct or indirect violence.

Displacement.—If the fracture is in the upper third of the shaft of the radius, above the insertion of the pronator radii teres, the proximal fragment will be held supinated and flexed by the pull of the supinators. If the fracture lies below the insertion the upper fragment is likely to be in the mid position The original displacement is due to the direction of the fracturing force, but the pull of the flexors and extensors tends to maintain the angulation or overriding

Diagnosis.—When there is displacement with visible deformity the diagnosis is evident. *X* ray examination, however is essential to show the obliquity or comminution of the bone ends

Pathology—In adults, in whom considerable violence is needed to break the bones there is usually fairly extensive soft part damage with hemorrhage beneath the deep fascia and impairment of circulation. Cases of Volkmann's ischemic paralysis have been reported In children on the other hand in whom green-stick fractures are of frequent occurrence with relatively little violence swelling and hemorrhage may be minimal. Damage to one or more of the nerves of the forearm frequently accompanies severe injuries

Treatment.—In children a satisfactory form of treatment is closed reduction under anesthesia followed by immobilization in plaster splints. If the fractures are in the upper third reduction can best be accomplished by supinating and flexing

the lower fragment to bring it into position with the upper The extremity is then placed in anterior and posterior molded splints which extend from the shoulder to the metacarpal heads If the fractures are in the middle or lower third of the bones reduction can be carried out with the forearm at mid position Immobilization with a sugar tongs splint is satisfactory In green-stick fractures requiring reduction both cortices should be broken through during manipulation, otherwise the deformity will tend to recur

In adults fractures of both bones of the forearm present a problem Reduction may be accomplished, but because of the pull of the forearm muscles adequate position is difficult to maintain The use of Kirschner wires one through the ulna above and one through both bones below the fracture will aid materially in the maintenance of position These wires should be incorporated in circular plaster after the fractures have been satisfactorily reduced In many cases however open reduction with some form of internal fixation is the only way in which a satisfactory reduction can be obtained and held

Immobilization of fractures of the shafts of the forearm bones in both adults and children should be maintained for at least eight weeks Refractures occur with considerable frequency in this group and must be guarded against by prolonged immobilization Finger function must therefore be stressed during the period of splinting Persistent angulation or bowing of either bone may lead to a permanent limitation of rotation and should be avoided

Period of Immobilization.—Splints must be maintained for at least eight weeks and sometimes longer

Prognosis.—In children in cases where there is no angulation there is usually full functional return soon after the removal of splints. If bowing or angulation persists rotation may be permanently impaired In adults the prognosis should be guarded

Summary —

Proximal fragment supinated and flexed in fractures of the upper third of the shafts

In children closed reduction and splints for eight weeks

In adults Kirschner wires incorporated in plaster or operative reduction and fixation

Anatomical restoration important to function

FRACTURES OF A SINGLE BONE

Radius —**Occurrence** —Fractures of the radius most frequently occur in the lower third of the shaft and are caused either by direct or indirect violence They are common in children

Displacement.—The direction of the fracturing force determines to a considerable degree the angulation or overriding but rotary displacement is largely influenced by muscle action If the fracture line is above the insertion of the pronator radii teres the upper fragment is supinated and flexed if below it, the upper fragment usually remains in mid position and the lower fragment may be pronated and deviated toward the ulna. If the radius is shortened by overriding of the fragments or marked angulation dislocation of the ulnar head occurs

Diagnosis —The diagnosis is usually easy because of the visible and palpable position of the bone in the distal half of the forearm.

Pathology —There is usually less soft part damage associated with these fractures than with injuries to both bones *Nerve and large vessel lesions are rare. Delayed or non-union is not infrequent.*

Treatment.—This consists customarily of reduction and immobilization in splints. Reduction may be difficult because of the splinting action of the intact ulna and operation may occasionally be necessary If the fracture is in the upper

third of the shaft supination and flexion of the lower fragment are necessary to correct the displacement.

Time of Immobilization.—For fractures in the distal third of the bone splint protection should be maintained for four weeks. Fractures in the middle and upper thirds should be immobilized for from six to eight weeks

Prognosis.—Any residual deformity may result in limitation of rotation therefore prognosis should be guarded in adults In children full functional return is the rule

Summary —

- Frequent injury in children
- Closed reduction and immobilization in splints usual treatment
- Anatomical correction usually necessary for complete rotation

Ulna.—Fractures of the ulna are caused most frequently by direct violence because of the subcutaneous and vulnerable position of the shaft As has been said before fractures of the upper third with anterior displacement are associated with anterior dislocations of the radial head Fractures of the middle and lower thirds can usually be reduced by manipulation and held by sugar tongs splints

Delayed or non-union occasionally occurs and immobilization should be continued until there is evidence of bony healing

CHAPTER XI.

INJURIES AT THE WRIST

FRACTURES OF THE LOWER END OF THE RADIUS

Colles' Fractures.—**Occurrence** —Most frequent and best known of all fractures, the injury may occur at any age but is most frequently found in the older age groups. It is caused by a fall on the outstretched hand.

Displacement.—Because the fracturing force is directed upward and backward the displacement of the lower fragment is in the same direction This displacement may be manifested as a tilt of a few degrees merely straightening the normal volar curve of the radius as a shift extending the entire width of the bone or any combination of tilt and shift between these two extremes. There is usually impaction and because the force of the trauma is up as well as back this is frequently most marked at the dorsal cortex. The distal fragment may be in one piece or comminuted sometimes with fracture lines into the articular surface. Shortening of the radius because of the impaction or in rare cases, overriding will cause a radial deviation of the hand. There may be an actual radial shift of the lower fragment. Rotation deformity may also occur A fracture of the ulnar styloid is usually an associated lesion. In other words a Colles fracture may show any displacement, from an almost imperceptible angulation with no other deformity to dorsal shift and tilt, impaction shortening and radial shift.

Diagnosis.—The normal anatomy of the wrist and the relationship of the hand to the forearm must be appreciated before deviations from the normal can be determined A line drawn through the middle of the forearm normally meets a line drawn through the third metacarpal at the level of the

wrist joint (Fig 58) Because of the curving shape of the radial articular surface there is a slight ulnar deviation of the hand when the upper extremity hangs relaxed (Fig 58) The volar surface of the lower radius is slightly concave which gives a visible curve to the volar aspect of the lower third of the forearm (Fig 59) The dorsal surface is relatively flat The plane of the articular surface of the radius

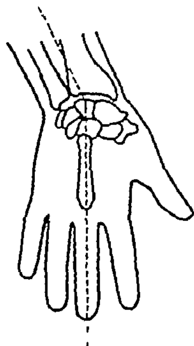


FIG. 58.—Dorsal view of normal wrist showing ulnar deviation of hand

inclines slightly volarward (Fig 59) On palpation the radial styloid is felt about 0.5 cm. distal to the ulnar styloid (Fig 58) The dorsal surface of the lower extremity of the radius feels rough and irregular because of the grooves in the bone through which the tendons pass.

The "silver fork deformity described in every text-book is caused by the dorsal displacement of the lower fragment. There are also usually present a radial shift or tilt of the

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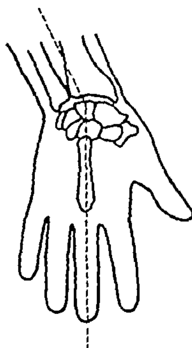


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The "silver fork deformity described in every text-book is caused by the dorsal displacement of the lower fragment There are also usually present a radial shift or tilt of the

hand a loss of the volar concavity of the wrist, and a shortening of the radius with a change in the styloid relationship

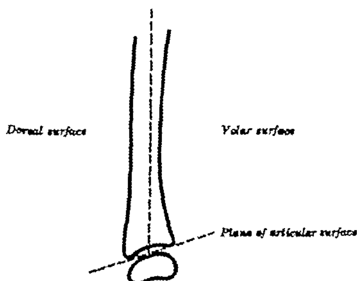


FIG 59 — Lateral view of normal wrist.

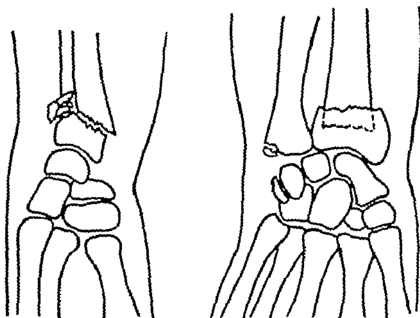


FIG 60.

(Fig 60) Where there is gross displacement the diagnosis is easy Where there is little or no displacement the direct and indirect tenderness over the lower end of the radius coupled with the history of the injury should lead the examiner to suspect a fracture *X*-ray films should always be taken to show the exact nature of the injury

Pathology—Because the fracture is through cancellous bone the presence of comminution is of extreme importance from a standpoint of prognosis. When the fracture is reduced there may be left a wedge-shaped gap in the dorsal surface which is filled with soft bone fragments and will take long to heal In such cases the deformity may recur if adequate protection is not maintained for a sufficient period If shortening of the radius is allowed to persist the relationship of the bones at the inferior radio-ulnar joint will be disturbed and may result in pain on rotation If the distal fragment is shifted dorsally to a considerable extent there may be pressure on the median nerve and the flexor tendons as they pass over the projecting anterior end of the proximal fragment (Fig 61) Fortunately this complication is not frequent, but the condition of the median nerve must always be tested Swelling especially of the hand and fingers may be a distressing complication and should be combated from the initial treatment.

Treatment.—Immediate reduction under either general or local anesthesia should be done If seen early these fractures can be reduced very satisfactorily with the injection of novocaine into the hematoma at the fracture site Manipulation should not be according to any set of rules but according to the needs of the individual fracture It should be remembered that impaction must always be overcome by steady traction and a gentle rocking motion before the distal fragment can be brought forward and down into place The shortening must be overcome by traction the dorsal shift or angulation by pressure in a volar direction and the radial shift by pressure on the distal fragment toward the ulna.

After the fracture is reduced satisfactorily, i. e., when the normal anatomical relations have been restored, it should be immobilized in some form of anterior and posterior splints. A sugar tongs splint is very satisfactory The wrist should be placed in palmar flexion and ulnar deviation to maintain

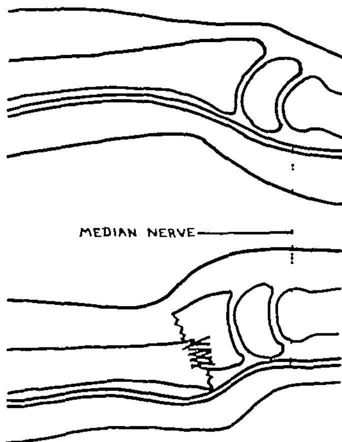


Fig. 81

the reduction If there has been no displacement the acutely flexed position at the wrist is undesirable a slight cock-up position being preferred Where there has been gross dorsal comminution so that there is a gap in the bony structure on the dorsal surface the time of immobilization must be pro-

longed In such cases it is frequently wise to replace the splints by a plaster gauntlet after the initial swelling has gone down. Splint or gauntlet should not extend beyond the mid-palmar crease, as finger motion and use of the hand should be started from the beginning There are certain few cases where the fragmentation is so great that the position cannot be held by splints or gauntlet. In these cases it is wise to insert two Kirschner wires, one through the bases of four medial metacarpals and one through the radius and ulna above the fracture With traction and countertraction exerted on the wires, the fragments can be molded into position and held there while circular plaster is placed around the wrist incorporating the two wires The wires will maintain the length of the bone during the healing period Active motion of the fingers must be insisted on In simple uncomplicated cases the splints should be kept on from two and a half to three weeks and then replaced by a protective wristlet for another week or two weeks Where there has been no displacement the period may be considerably shortened and the patients started on hot soaks and gentle massage within the second week. In the elderly and in those cases where function is more important than appearance, early active motion may be started from the beginning and reduction dispensed with If there has been gross dorsal comminution it may be necessary to keep the wrist immobilized for from four to six weeks and if wires have been used they should be kept *in situ* for six weeks

Time of Immobilization.—Simple cases should be immobilized about two weeks more severe types for from three to four weeks, more comminuted cases from four to six weeks those with double wires, six weeks.

Prognosis.—Where there has been little or no displacement in a relatively young person there should be full return of function in two or three months. In the older group where there is dorsal comminution the prognosis should be guarded

for there may be residual deformity limitation of flexion and pain in the radio-ulnar joint on rotation

Summary —

The most common type of fracture

(1) Dorsal prominence of lower end of radius, (2) loss of volar concavity of lower forearm, and (3) radial tilt of hand most frequent deformities.

Early reduction and immobilization with splints.

Double Kirschner wires valuable in severely comminuted cases.

Operation rarely necessary

Residual deformity possible source of painful motion.

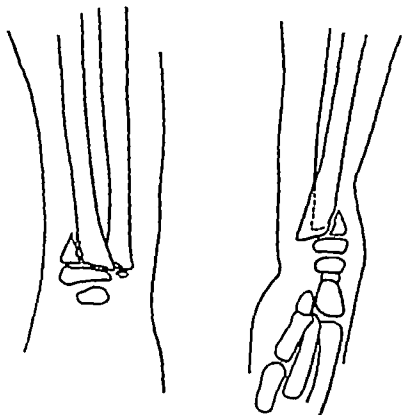
Reverse Colles Fractures —These injuries are infrequent and are caused by a blow or fall on the dorsum of the hand the fracturing force being directed anteriorly The lower fragment of the radius is displaced forward and may or may not be comminuted Reduction under anesthesia is frequently possible and the wrist should be immobilized with the hand held in the cock-up position A sugar tongs splint is a satisfactory means of immobilization Some of these fractures are difficult to reduce and hold and operation may be necessary though it offers certain technical difficulties.

Separation of Lower Radial Epiphysis.—**Occurrence** —These are very common injuries of childhood and are caused by a fall on the outstretched hand.

Displacement.—The radial epiphysis slips posteriorly and somewhat proximally almost invariably taking with it a wedge-shaped fragment from the posterior edge of the diaphysis (Fig 62) The amount of displacement may be anything from 1 to 2 mm to the entire width of the shaft.

Diagnosis.—A "silver fork deformity at the wrist of a child suggests either an epiphyseal displacement or a fracture in the lower third of the radial shaft Frequently an *x*-ray film is the only means of differentiation between the two lesions In injuries to the wrist with no resulting deformity,

tenderness over the epiphyseal line, swelling and disability strongly suggest a fracture through the epiphyseal cartilage Early *x*-ray plates show no evidence of such injury and the diagnosis must be made on the clinical picture *X*-ray films taken two or three weeks after the injury may show a small line of subperiosteal callus extending a short distance up the shaft.



Antero-posterior view *Lateral view*
Fig 62.—Separation of lower radial epiphysis

Pathology —There is frequently not much swelling and rarely are there nerve or vessel complications The late complication is that of growth disturbance and apparently the extent of displacement is no indication for the presence or absence of such a disturbance

Treatment.—Reduction under an anesthetic is usually very simple if the case is seen early Immobilization in splints for two or three weeks is all that is necessary in most cases. Where the case is seen late, open replacement of the epiphysis may be necessary in order to prevent persistent deformity

Time of Immobilization.—From two to three weeks.

Prognosis.—Complete functional return is usually very prompt, but growth disturbances may occur as late as two or three years after injury and the parents should always be warned of this fact. There is no known way to prevent it.

Summary—

- Frequent injury in childhood
- Dorsal displacement usual.
- Manipulative reduction and splints for from two to three weeks.
- Growth disturbance a possible complication

FRACTURES OF THE CARPUS

Fractures of the Navicular (Scaphoid)—**Occurrence**—This is the most frequently injured bone of the carpus and usually occurs in young and active adults. It is usually caused by a fall on the outstretched hand

Displacement.—Displacement of either the distal or the proximal fragment is quite rare and occurs usually after a severe injury Occasionally the proximal fragment may be displaced anteriorly with a dislocation of the lunate (semi lunar) bone Frequently however there is no displacement of either fragment.

Diagnosis—The differential diagnosis between a fracture of the navicular and a sprain of the wrist is of great impor tance for a failure to recognize a fracture and immobilize it may be responsible for the development of a non union. Characteristic signs of a fresh fracture of a navicular are swelling over the carpus, frequently with evidence of a hem arthrosis, tenderness over the navicular (especially on the

volar surface), indirect tenderness elicited by pressure on the thumb upward toward the radius, pain on rocking the navicular on the radius pain on radial deviation of the hand, limitation of flexion and extension of the wrist on the forearm Tenderness on pressure in the anatomical snuff-box is not definite evidence of fracture unless it is more marked than the tenderness produced by similar pressure on the uninjured wrist. Characteristic signs of a sprained wrist are diffuse swelling without hemarthrosis, generalized tenderness usually over the dorsum of the wrist, no indirect tenderness vague pain on rocking the navicular, quite different from the sharp pain of the fractured bone, because of the strain on the torn ligaments and pain on ulnar deviation of the hand if the radial collateral ligament is torn

X ray pictures must be taken in the oblique as well as in the antero-posterior and lateral planes to show the complete bone The hand should be so placed that the radial side is next the film Negative *x* ray films do not rule out a fracture of the navicular and the physician must be guided by the clinical picture for his diagnosis.

Pathology —The bone usually breaks at its mid portion or at the junction of the middle and proximal thirds Because of the poor blood supply of the proximal third with its lack of soft part attachments, fractures in this area frequently do not unite. The fractures in the distal third, however almost always unite. Because of the position and character of the bone soft part damage is usually negligible

Treatment.—As soon as the diagnosis is made the wrist should be immobilized in a plaster gauntlet extending from the mid-palmar crease to the elbow and including the proximal phalanx of the thumb The hand should be placed in slight radial deviation and in mid-position with possibly a slight cock-up The thumb should be abducted Extreme cock-up should be avoided because of the tension it puts on the anterior circulation of the navicular The gauntlet should be maintained for eight weeks in all cases of fracture

through the middle or proximal thirds in fractures through the distal third the time may be cut down to four or six weeks During this period the patient should use his hand as much as possible At the end of eight weeks the gauntlet should be removed and x-ray films made. If these show an increase in the width of the fracture line or no evidence of healing the gauntlet should be reapplied for a second eight weeks. If healing is progressing satisfactorily however a protective wristlet is all that is necessary Recently an operation to aid bone union has been devised for both early and late cases.[1] The two fragments are drilled and a small autogenous graft is inserted into the drill holes. In late cases where no union has occurred removal of either part or all of the navicular may be necessary to give a painless wrist.

Time of Immobilization.—In most cases eight weeks are necessary

Prognosis.—For cases of fractures in the middle and especially in the proximal thirds the prognosis should be guarded as to healing Non-union of the scaphoid may give a weak and painful wrist.

Summary —

- Frequently confused with sprains of the wrist.
- Diagnosis based on clinical picture
- Treatment prolonged immobilization in plaster of Paris
- Non-union not uncommon in fractures of proximal third

Fractures of the Other Carpal Bones —Fractures of the other carpal bones are unusual but occasionally a small chip fracture may be associated with a severe sprain. Because of the size and position of the bones they are usually seriously injured only in severe crushing accidents. Immobilization for from four to six weeks is frequently all that is necessary

[1] Murray Gordon Bone Graft for Non-union of the Carpal Scaphoid Surg., Gynec. and Obst., 60 2A 1935.

DISLOCATIONS OF THE CARPAL BONES

Dislocation of the Lunate.—Occurrence.—This is the most frequent dislocation of the carpal bones It is not a common injury but should be recognized when it occurs It is usually caused by a fall on the hyperextended hand

Displacement.—The force of the blow drives the distal carpal bones backward and upward widening the space between the capitate and the radius anteriorly When the

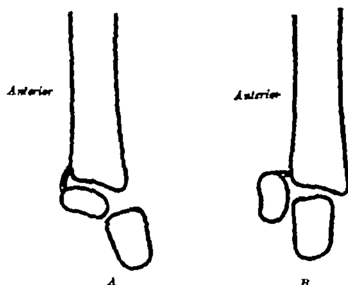


Fig 63 —Showing mechanism of lunate dislocation.

force ceases the bones slip back into place, popping the lunate out anteriorly as a watermelon seed is popped between the fingers (Fig 63) The strong anterior radio-lunate ligament remains intact and the bone may pivot on this ligament 90 to 180 degrees (Fig 63)

Diagnosis.—Recent cases present a swollen wrist joint with tenderness and fulness in the anterior carpal canal There is limitation of wrist motion and of flexion of the fingers There is frequently evidence of median nerve damage because of the pressure of the lunate in the carpal canal Late cases in

which the condition has been overlooked frequently consult a doctor because of an annoying anesthesia of the fingers over the median nerve distribution Lateral x-ray films carefully studied easily confirm the diagnosis.

Pathology—Because of the strong anterior carpal ligament there is pressure on the contents of the canal *i. e* the flexor tendons and the median nerve when the lunate is displaced into the carpal canal Disability caused by such pressure is the outstanding complication

Treatment.—Reduction under anesthesia should be attempted in all fresh cases. It can be accomplished by long and steady traction to separate the capitate from the radius and extension of the hand to open up the carpo-radial joint anteriorly At the same time on the volar surface of the wrist, pressure is exerted from above downward and dorsally on the lunate. While traction is maintained the hand is then pulled into flexion as the lunate slips back into place. The wrist should be protected by some form of splint for about three weeks but active use of the fingers should be encouraged. If the case is not seen early or if reduction by closed means is not successful open reduction should be done. In late cases removal of the bone from the carpal canal is necessary

Time of Immobilization.—Approximately three weeks.

Prognosis.—If early reduction has been accomplished functional return will probably be complete in a couple of months. Removal of the lunate in late cases may be followed by a weak and painful wrist.

Summary—

Most common carpal dislocation
Median nerve pressure frequent complication
Reduction under anesthesia treatment for early cases.
Operative removal of bone usually best in late cases

CHAPTER XII

INJURIES TO THE HAND

FRACTURES OF THE FIRST METACARPAL.

Occurrence.—This injury occurs most frequently in active young adult males as its causative factor is most frequently a fight.

Displacement.—The most common site of fracture is at the base of the metacarpal where it articulates with the greater multangular (trapezium). Because of the direction of the force the shaft is displaced to the radial side and driven proximally (Fig. 64). Sometimes the fracture line includes part of the articular surface.

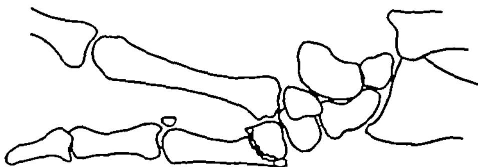


Fig. 64

Diagnosis.—There is usually considerable swelling of the thumb with a prominence on the radial side of the base of the first metacarpal. There is frequently shortening and the deformity is both visible and palpable. Tenderness both direct and indirect, is present.

Pathology.—There is likely to be considerable damage to the tissues of the thenar eminence, but except for the swelling complications are exceedingly rare.

which the condition has been overlooked frequently consult a doctor because of an annoying anesthesia of the fingers over the median nerve distribution. Lateral x-ray films carefully studied easily confirm the diagnosis.

Pathology —Because of the strong anterior carpal ligament there is pressure on the contents of the canal, *i. e* the flexor tendons and the median nerve when the lunate is displaced into the carpal canal. Disability caused by such pressure is the outstanding complication

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Time of Immobilization.—Approximately three weeks.

Prognosis.—If early reduction has been accomplished functional return will probably be complete in a couple of months. Removal of the lunate in late cases may be followed by a weak and painful wrist.

Summary —

Most common carpal dislocation

Median nerve pressure frequent complication.

Reduction under anesthesia treatment for early cases.

Operative removal of bone usually best in late cases.

metacarpal is usually obvious Fractures of the base where the deformity is minimal are more difficult to diagnose but should be suggested by direct and indirect tenderness and swelling X ray examination is essential

Pathology—Swelling is apt to be considerable Nerve and blood vessel injuries are fortunately rare Residual anterior angulation of the metacarpal head may result in a painful grip because of the bony prominence in the palm

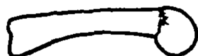

Fig. 65


Fig. 66.

Treatment.—Fractures near the head of the bone should be reduced and the knuckle brought up into place because a slight deformity with the projection of the metacarpal head into the palm may result in a serious economic handicap Deformity of the fifth metacarpal is not as disabling as that of the other three because it interferes less with the strength of the grip Because of the smallness of the distal fragment it is sometimes very difficult to reduce the fracture without the use of some mechanical means like a small Thomas wrench. Following reduction the finger should be placed at right angles over a volar splint which will force the knuckle dorsally ¶This should be maintained for three or four weeks Occasionally traction either skin or skeletal, may be necessary

Fractures of the shafts of the metacarpals may be reduced by manipulation and held in plaster if they are transverse If they are oblique traction, preferably by a wire through the proximal phalanx is usually necessary A banjo splint (Fig 67) of some type is used for the traction apparatus.

Fractures of the base need protection for a short period only until the immediate swelling and tenderness have subsided. The usual splinting time for displaced fractures of the metacarpals is four weeks. As much finger motion as

Treatment.—Because of the small size of the proximal fragment and of the extreme mobility of the thumb, these fractures are *difficult to hold in position* Reduction can usually be accomplished by manipulation, but frequently unless traction is continuous the deformity is likely to recur In some cases a satisfactory position can be maintained with a carefully molded plaster gauntlet with the metacarpal held in abduction Usually however such an apparatus must be augmented by traction strips of adhesive plaster or by skeletal traction by means of a wire through the proximal phalanx. Occasionally it is necessary to pull the thumb across the palm in adduction to relax the pull of the adductor and opponens muscles Immobilization should be maintained for about four weeks

Period of Immobilization.—Four weeks

Prognosis —In spite of residual deformity adequate functional return within a relatively short time is the rule.

Summary —

Injury received in a fight
Radial displacement of distal fragment.
Traction usually necessary to maintain reduction
Deformity usually not a handicap to function

FRACTURES OF THE OTHER METACARPALS

Occurrence —These injuries are common in the active age group and may be produced by either direct or indirect violence. Fighting is frequently a cause.

Displacement.—Many of the fractures occur at the neck of the bone and the resultant deformity is that of a dropped knuckle because the head is displaced anteriorly (Fig 65) Fractures of the shaft are usually oblique with overriding and dorsal angulation (Fig 66) Fractures of the base rarely show displacement

Diagnosis.—Because of the ease of palpation of the bones on the dorsum of the hand the diagnosis of fracture of the

Displacement of shaft fractures, angulation with apex dorsally frequent overriding
Manual reduction and immobilization or traction
Restoration of anatomy important in fracture of second and third metacarpals.

FRACTURES OF THE PHALANGES

These injuries are frequently caused by crushing or shattering blows and are extremely common especially among manual laborers Adequate treatment is of great economic importance because a crippled finger may terminate or markedly diminish the working life of a skilled laborer Diagnosis of these conditions is usually easy Small chip fractures, however may not be recognized clinically and x ray films should be taken of all so-called sprained fingers. The treatment of the undisplaced fractures is relatively simple Any form of protection, such as a padded tongue depressor splint a metal splint or a small molded plaster splint is satisfactory and should be maintained for from ten days to two weeks. If there is displacement reduction should be accomplished if possible If it is necessary to maintain traction the most effective means is that of a wire through the phalanx distal to the fracture. Adhesive plaster tends to slip traction through the nail may be extremely painful and traction by means of the Japanese basket apparatus may result in gangrene of the finger Traction should be maintained about three weeks. Occasionally the fracture line extends into the joint and there is considerable displacement of the fragment Open reduction in these cases may be necessary It should be remembered that active motion should be begun as soon as possible in order that the motion of the fingers may be preserved Crushing injuries of the distal phalanges usually need protection for about ten days Frequently they are extremely painful due to the pressure of the subungual

possible should be encouraged during the period of immobilization, and as soon as the splints are removed active motion of the hand and hot soaks should be instituted

Time of Immobilization.—Four weeks.

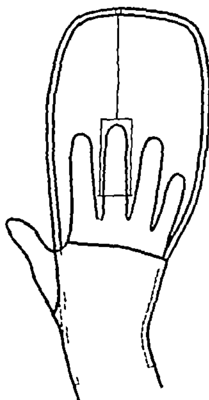


Fig. 67

Prognosis —If the deformity has been corrected the return to function should be complete in about three months. If, however, wire traction has been used there may be delay in the return of finger motion

Summary —

Frequent injuries.

Displacement of neck fractures forward tilting of head

from the metacarpal and drops between the phalanx and the metacarpal head (Fig 68) The long flexor tendon will slip to one side or the other of the metacarpal The deformity is obvious, but the reduction may be very difficult if not impossible by closed means. Hyperextension of the thumb with traction and a kind of "milking motion in an attempt to slip the interposed capsule over the head of the metacarpal, may sometimes reduce the dislocation Usually open reduction is necessary Immobilization in slight flexion for about ten days following reduction is wise The motion in this joint following open reduction is sometimes quite limited but does not seem to be a handicapping disability

Dislocations of the other metacarpo-phalangeal joints are less frequently seen Because of the thickened volar portion of the capsule (glenoid ligament) which is loosely attached to the metacarpal but firmly attached to the phalanx they present to a somewhat slighter degree the same problem as do the dislocations of the thumb If the capsule slips between the phalanx and the metacarpal, reduction by closed means may be very difficult and accomplished only by hyperextension, traction and a milking motion to force the interposed capsule out of the joint. Flexion as a means of reduction is dangerous for it may convert a simple into a complex dislocation

Dislocations of Interphalangeal Joints —These dislocations are easily recognized and almost as easily reduced by manual traction if seen early Immobilization by some simple splint for about ten days is all that is necessary *X*-ray films should be made to rule out small fractures.

hematoma, and great relief can be obtained by drilling the nail and releasing the blood

The prognosis of these injuries should be guarded because it is surprising how delayed the return of function may be, even when the initial injury seems slight.

Baseball fingers or avulsion of the extensor tendon from its insertion into the distal phalanx should be treated by a hyperextension splint for a full six weeks. These injuries are very difficult to repair satisfactorily by open means but heal well if they are immobilized in hyperextension long enough

DISLOCATIONS OF THE METACARPALS AND PHALANGES

Dislocations of the Metacarpo-phalangeal Joints —Dislocations of the first metacarpo-phalangeal joint are sometimes



Fig 68.—Complex dislocation of the thumb.

complicated A complex or complete dislocation occurs when the metacarpal head slips anteriorly between the heads of the flexor brevis the volar portion of the capsule which is thickened and fibrocartilaginous (glenoid ligament) tears

PART III

THE TRUNK

PERCENTAGE OF OCCURRENCES

	Per cent of all fract.	Per cent of all disloc.	Per cent of total injuries.
Injuries to the chest			
Ribs[1]	4 38		4 14
Injuries to the spine.			
1 Fractures of the vertebral body	1 11		1 00
2. Fractures of the transverse process	1 07		0 97
3. Dislocations of the vertebræ		10 19	1 50
Injuries to the pelvic girdle.			
1 Fractures of the ilium	0 21		0 18
2. Fractures of the ischium and pubis	0 45		0 41
3 Fractures of the acetabulum	0 07		0 07

CHAPTER XIII

INJURIES TO THE CHEST

FRACTURES OF THE RIBS

These injuries are usually due to direct violence and are very common The diagnosis is suggested by linear bony tenderness by indirect tenderness caused by compression of the chest and by pain particularly on deep inspiration and cough If a single rib is cracked the treatment consists of immobilization by adhesive strapping or by a swathe going completely around the chest, which is more satisfactory in women If several ribs are broken strapping is frequently unsatisfactory because it increases the pain and discomfort for the patient. Rest in bed with external heat and such general measures as the patient requires are the best forms of treatment Occasionally complications such as hemothorax or pneumothorax occur and should be treated symptomatically

[1] Computed as per number of patients, not number of fractures.

suspected The physical signs may be very few, the most constant being tenderness over the spinous process of the affected vertebra Protective muscle spasm is also frequently present. In severe cases a visible or palpable kyphosis or a flattening of the lumbar lordosis may be evident. The diagnosis is confirmed by lateral x-ray films of the spine Antero-posterior films may not show the lesion Early diagnosis is essential Unrecognized compression fractures with little or no deformity at first may continue to compress with the weight of the body and increase the displacement if the vertebral column is not supported in extension

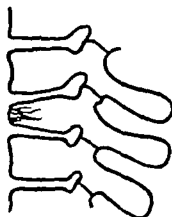


Fig. 00.

Pathology — Because of the crushing nature of the injury the strong anterior vertebral ligament is not usually torn There may be considerable hemorrhage even a retroperitoneal hematoma which may give signs and symptoms suggestive of an intra-abdominal injury Occasionally there may be associated fractures of the posterior elements. Fractures accompanied by serious cord injuries will be discussed later

Treatment.—The injury is caused by hyperflexion therefore the reduction is brought about by hyperextension The intact anterior ligament is of importance in pulling out the compressed cancellous bone. Hyperextension may be accomplished either by direct manipulative reduction or by a somewhat more gradual reduction on a frame taking from fifteen to twenty minutes. A third method of even more gradual reduction may be used It consists in the placing of the patient on a frame with gradual hyperextension of the spine over a period of from twenty four to forty-eight hours. Whatever the method employed the principle of hyperextension is the same Various frames have been devised for

CHAPTER XIV

INJURIES TO THE SPINE

First Aid Treatment.—In no other injury is the first aid treatment of more importance than in spinal injuries. It is possible by injudicious handling of the patient to damage the spinal cord and make a hopeless paralytic out of a patient who might have been returned to full activity All patients who are suspected of having an injury to the back should be lifted face downward on a board a stretcher or a rug so that the spine is kept extended The usual method of lifting a patient by shoulders and hips will allow the spine to flex and should never be used If there is no board or rug at hand it is still possible to lift the patient face down if there are enough assistants

FRACTURES OF THE VERTEBRAL BODY

Occurrence —This fracture is probably the most frequent injury to the spine It is caused by a fall on the feet or on the buttocks causing a jack knifing or sudden flexion of the spinal column

Displacement.—The characteristic deformity is an anterior wedging of the vertebral body (Fig 69) which in extreme instances may produce a visible kyphosis. The injury may take place at any level but usually is seen at the dorso-lumbar junction The vertebral body is crushed between the vertebra above and the vertebra below

Diagnosis.—The history of a fall on the feet or buttocks or of a heavy weight landing on the head and shoulders flexing the body should suggest the possibility of a compression fracture. Many of the patients are able to walk from the accident and may even return to work, though complaining of a backache. Frequently therefore the lesion is not

and should be carefully watched and controlled by rectal treatments Rectal and bladder symptoms are not uncommon but usually clear up rapidly

Time of Immobilization.—Eight weeks in plaster

Prognosis—In those cases where the diagnosis has been made early and treatment promptly instituted the prognosis should be good In late cases where correction has not been obtained weakness and backache may persist. Spinal fusion may be necessary

Summary—

- A frequent back injury caused by sudden flexion of the trunk
- Diagnosis suggested by backache and tenderness over the affected vertebra confirmed by lateral *x* ray plates
- Treatment hyperextension and immobilization in a plaster jacket for eight weeks

Fractures With Cord Injury—These cases caused by serious trauma demand expert care Careful reduction of the bony deformity at the earliest possible moment is essential because the correction of the deformity may relieve the pressure on the cord If the cord has been completely severed or crushed the general care of the patient to avoid bed-sores and bladder infection is the first consideration If however the paralysis is due to pressure on the cord by displaced bone reduction may relieve the symptoms In certain cases laminectomy is indicated for the relief of pressure

FRACTURES OF THE TRANSVERSE PROCESS

These injuries usually occurring in the lumbar vertebræ may be due to direct violence or to muscle pull Of chief concern is the soft part injury and the fracture should be minimized especially to the patient The bone injury is negligible Heat, massage and other forms of physical therapy for the muscle damage followed by adhesive strapping if necessary are usually all the treatment that is required

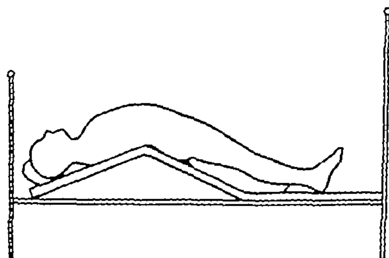


FIG. 70.



FIG 71

the purpose, but the use of a reversed Gatch bed is quite satisfactory for the gradual extension (Fig 70) Following the reduction which should be checked by x ray films a plaster jacket is applied to maintain the position The jacket should be well molded to the contours of the body and should extend from the suprasternal notch to the symphysis pubis in front and include the lumbar region behind (Fig. 71) The plaster should be worn for approximately eight weeks, and during that time if the compression is in the low dorsal or lumbar region the patient may be ambulatory He should be encouraged to do exercises to strengthen his back muscles After the removal of the plaster jacket a Taylor spinal brace may be worn for four months while the patient continues to go about his business In some instances this is not necessary Abdominal distention may be a complicating factor in the first days of treatment

CHAPTER XV

INJURIES TO THE PELVIC GIRDLE

FRACTURES OF THE ILIUM

These injuries are usually due to direct violence. Occasionally, however, the anterior-superior spine may be avulsed by muscle pull. The importance of fractures of the iliac ala is that of the soft part damage involved, as the bone will heal in most instances without complication of any kind. Deformity does not usually result in disability. The treatment consists of rest in bed with physical therapy for the contused and lacerated soft parts. Weight-bearing can usually be resumed in about four weeks. If the anterior-superior spine is torn off, the thigh should be kept flexed on the body to relax the muscle pull.

FRACTURES OF THE ISCHIUM AND PUBIS

If a single ramus is involved, gross displacement cannot occur because of the splinting action of the other ramus. The diagnosis is suggested by tenderness directly over the pubis and is confirmed by x-ray examination. Treatment consists of rest in bed for about four weeks.

If two or more rami are fractured, the problem is more serious. These injuries are frequently due to severe crushing accidents and may be associated with bladder or urethral damage. The diagnosis of pelvic injury is suggested by tenderness and in some instances palpable deformity of the pubis. Lateral compression of the iliac crests will produce indirect tenderness at the sites of fracture. The patient may be in severe shock, depending on the extent of the soft part damage. All these patients should be investigated for evidence of bladder injury, and a specimen of urine should be obtained as soon as possible for examination for red blood cells. The bladder injury, if present, is of prime importance. A laparotomy may be necessary. The fractures, if displaced, can be treated by traction on the legs with a canvas sling

DISLOCATIONS OF THE VERTEBRÆ

The most frequently dislocated vertebræ are the cervical because of the wide range of motion which can take place in that region. A complete dislocation may be caused by diving accidents, automobile injuries and similar traumata. The head is held tilted to one side and turned to the other with considerable pain and limitation of motion. *X*-ray pictures confirm the diagnosis Expert treatment is essential and usually consists in reduction under an anesthetic Care must be taken during the manipulation to keep the neck extended in order to protect the spinal cord Following reduction a plaster collar should be worn approximately eight weeks followed by a protective leather collar for six months. It is important that in all neck injuries films should be taken showing the odontoid process, because an undetected fracture of this bone is a source of great danger to the patient. With such an injury unprotected, a sudden jerk of the head may displace the fragment and cause instant death

Incomplete dislocations of the cervical vertebræ are relatively frequent. They are caused by mild twisting traumata and are characterized by an inability to bend the neck to one side. Stereoscopic *x*-ray films taken in the lateral plane demonstrate a slight upward shift of one articular facet on its neighbor Head traction will reduce fresh lesions in a few hours. Longer traction is necessary in those cases where the displacement has persisted for some time Following reduction some form of protection is usually necessary for a short time depending on the ease with which the reduction has been accomplished Where the reduction has been very difficult a plaster collar may be necessary for three or four weeks Otherwise a Shantz collar of cotton and muslin for a period of a week or ten days is all that is necessary

under the pelvis Care must be taken not to have lateral pressure on the pelvis which will tend to increase the over riding of the fragments. The traction should be maintained for from six to eight weeks and then the patient may be allowed to get up The prognosis in spite of bony irregularity is usually good if the patient survives the initial injury In women of child-bearing age or younger, restitution of the shape of the pelvis is important because of possible interference with childbirth.



Fig 72

FRACTURES OF THE ACETABULUM.

These injuries may be caused by a blow on the outer side of the hip driving the head of the femur into and in some instances through the acetabulum Treatment is replacement of the head of the femur by closed manipulation if it has been driven through into the pelvic cavity or by traction if there is not much displacement. The best form of traction is that which combines lateral with longitudinal pull (Fig 72) It should be maintained from for four to six weeks and the patient then allowed up for active motion without weight-bearing for another six to eight weeks Prognosis of these cases should be somewhat guarded as traumatic arthritis may be a late complication

PART IV

THE LOWER EXTREMITY

PERCENTAGE OF OCCURRENCES

	Per cent of all fract.	Per cent of all disloc.	Per cent of total injuries.
Injuries at the hip-joint	1.99		1.79
1 Fractures of the upper extremity of the femur			
Intracapsular	1.21		1.12
Intertrochanteric	0.45		0.41
Subtrochanteric	0.07		0.065
Separation of the upper femoral epiphysis	0.06		0.056
2 Dislocations at the hip		0.45	0.047
Fractures of the shaft of the femur	1.10		0.99
Injuries at the knee-joint.			
1 Fractures of the lower extremity of the femur	0.28		0.25
Separation of the lower femoral epiphysis	0.11		0.10
2 Fractures of the patella	0.59		0.54
3. Fractures of the upper extremity of the tibia	1.16		1.05
Fractures of the tibial spine	0.21		0.18
Fractures of the shafts of the tibia and fibula	1.53		1.38
Injuries at the ankle-joint.			
1 Fractures of the malleoli.			
Fractures of lateral malleolus	2.72		2.46
Fractures of both malleoli	0.58		0.52
Pott's	0.26		0.23
2. Fractures of the lower extremity of the tibia.			
Separation of epiphysis	0.97		0.88
3. Dislocations at the ankle-joint		3.18	0.31
Injuries to the foot.			
1 Fractures of the tarsus	1.36		1.23
2. Fractures of the metatarsals	3.30		2.97
3 Fractures of the phalanges	2.99		2.71
4 Dislocations (at the metatarso-tarsal joints)		0.39	0.04

CHAPTER XVI

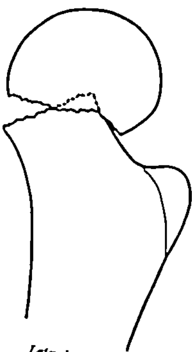
INJURIES AT THE HIP-JOINT

FRACTURES OF THE UPPER EXTREMITY OF THE FEMUR.

Intracapsular Fractures.—Occurrence —These injuries are among the most frequent that occur in old age They are rarely seen in young adults and far more often in women than in men They are commonly caused by such a mild trauma as a fall from slipping on a rug

Displacement.—The distal fragment is usually externally rotated and displaced upward on the head (Fig 73) The end of the shaft may lie in front or behind the head fragment or the two fragments may be impacted. Occasionally the fractured surface of the head lies against the side of the neck The shaft is frequently adducted

Diagnosis.—Every individual over middle age who complains of pain in the hip following a fall should be considered to have a fracture of the hip until proved otherwise. The patient usually lies with the affected leg in marked external rotation Measurements from the anterior-superior spine to the internal malleolus may show a difference between the two sides with shortening on the affected side In such cases a line from the anterior-superior spine to the ischial tuberosity will pass below the tip of the greater trochanter instead of through it (Nélaton s line) With the patient supine a line dropped from the anterior-superior spine perpendicular to the table and one from the anterior-superior spine through the tip of the greater trochanter form a triangle with the table as the base (Bryant s triangle) A comparison of the triangles of the two sides will show that the base on the affected side is shorter (Fig 74) Any motion of the hip



Lateral view

Antero-posterior view

Fig. 73.

causes pain Indirect tenderness may be produced by tapping on the heel of the extended leg There are cases where only pain and tenderness may be found where deformity is absent and the only evidences of fracture are the history of a fall some pain some limitation of motion and the sense of something wrong As has been said before these cases must be considered as fractures and *x* ray films taken not only in the antero-posterior but also in the lateral plane If this

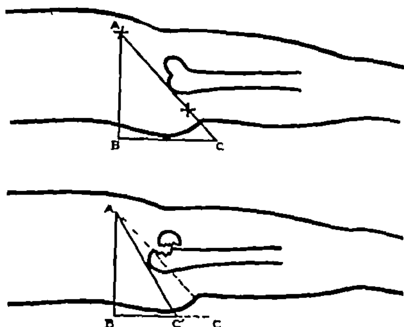


Fig. 74.—Bryant's triangle.

precaution is not observed and the patient is allowed to walk an impacted fracture may become disimpacted and displaced

Pathology —The capsule of the hip-joint is attached anteriorly to the intertrochanteric line and posteriorly to the outer third of the neck (Fig 75) There is, therefore a considerable portion of the neck which is entirely intracapsular and obtains its blood supply from the synovial vessels and from the vessels in the bone running in from the shaft.

The head receives part of its circulation from the vessels entering it by way of the ligamentum teres. The nearer the fracture line is to the head the greater is the chance for non-union

Treatment.—Reduction and immobilization until healing has occurred are the fundamental principles underlying the treatment of these fractures. Reduction is accomplished by traction to overcome the shortening outward pull to release the impaction internal rotation to correct the external rota

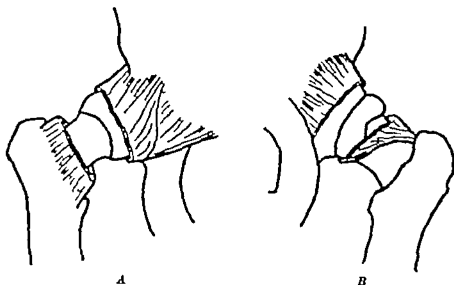


Fig. 75.—*A* Anterior *B* posterior

tion and finally abduction to hold the reduced fracture in position Various maneuvers have been described In the Whitman method the leg is manipulated with the thigh extended in the Leadbetter with the thigh flexed at right angles to the body The accuracy of the reduction can be tested by the Leadbetter sign This is demonstrated by balancing the heel of the extended leg in the palm of the operator s hand If the foot remains upright the fracture is reduced if the foot gradually swings outward into the externally rotated position reduction has not been adequately

accomplished Following satisfactory reduction checked by x ray films, a plaster spica may be applied to maintain the position This plaster should extend from the toes on the affected side to the axilla (Fig 76), or to the waist and include the opposite thigh in order adequately to immobilize the pelvis and maintain abduction (Fig. 77) The plaster should be carefully applied and thoroughly molded to the body The pa-

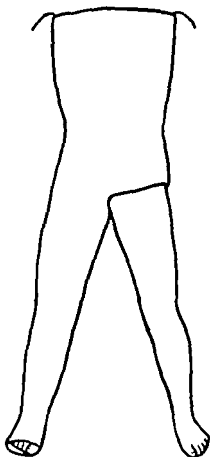


Fig. 76.

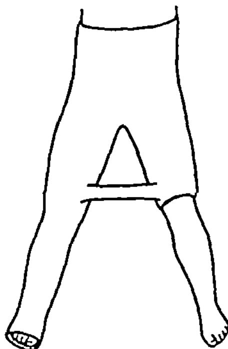


Fig. 77

tient must wear it for a minimum of eight weeks, usually from twelve to sixteen weeks. During that period she should be turned on her face at least twice a day to allow care of the back Scrupulous attention to the skin is the only way to prevent the unfortunate complication of pressure sores.

Because of the difficulty of keeping elderly people alive during such a course other forms of treatment have been devised Internal splinting by means of a three-flanged nail described by Smith Petersen is becoming increasingly popular The nail may be inserted through a large incision in which the capsule of the hip-joint is laid open and the fracture is reduced under direct vision, or through a small incision on the outer side of the thigh after the fracture has been reduced by closed manipulation Many different types of instruments are described to aid in the insertion of the pin but the underlying purpose is the same for all The pin fixes the shaft to the head in satisfactory position and holds it there while the bone heals. No other splint is necessary and the patient is allowed out of bed in about two weeks, though she puts no weight on the injured leg for about six months

Most of the patients with broken hips have some other complication such as arteriosclerosis, chronic cardiac disease or diabetes because they are in the elderly age groups and it may be necessary in certain instances to treat the patient and neglect the fracture. It is better to have a live patient with a poor hip than to have a beautiful anatomical reduction under ground At the present time the lateral nailing *i e* the insertion of the nail through a small lateral incision seems to be the best way of answering the problem of this group as the procedure is minimal and the patient can be out of bed very soon

Time of Immobilization.—When plaster is used the period may be anywhere from eight to twenty weeks, usually twelve to fourteen In all instances no weight-bearing should be allowed for at least six months.

Prognosis.—Except with the rare impacted fractures in valgus position which usually heal with solid bony union the prognosis for union in all cases should be guarded

Summary —

A frequent injury in elderly women following slight trauma

Characteristic deformity external rotation and shortening of the extremity

Treatment, reduction and immobilization by a plaster spica or by internal fixation preferably the Smith-Petersen nail

No weight bearing for at least six months

Delayed and non-union not infrequent, therefore guarded prognosis

Intertrochanteric Fractures —**Occurrence** —These injuries occur in about the same age group as the preceding possibly somewhat younger They are caused by a fall, usually directly on the thigh

Displacement.—The displacement depends not only on the injuring force but also on the position of the line of fracture Because of the strong muscles that attach to the trochanteric region the position of the upper fragment depends on the direction of pull of those muscles still attached to it. The lower fragment is usually displaced upward and is adducted the upper fragment may be externally rotated and flexed (Fig 78)

Diagnosis —Signs and symptoms are very similar to those of the intracapsular fractures and the deformity may be about the same *X* ray pictures in two planes are essential for accurate diagnosis

Pathology —Because of the excellent blood supply and the mass of soft parts surrounding this area, bony union is the rule rather than the exception It has been said that these fractures heal regardless of the treatment.

Treatment.—Reduction with immobilization in a plaster cast for about eight weeks is a satisfactory method Another almost equally efficient, is that of traction suspension preferably by means of a wire through the supracondylar region of the femur Operation with internal fixation presents mechanical difficulties because of the cancellous structure of the bone Whatever method is used the patient should be

allowed up in a Thomas caliper brace after union has taken place The brace should be maintained for about six months. Too early unprotected weight bearing may result in a varus deformity

Time of Immobilization.—The plaster or the traction should be maintained for about eight weeks.

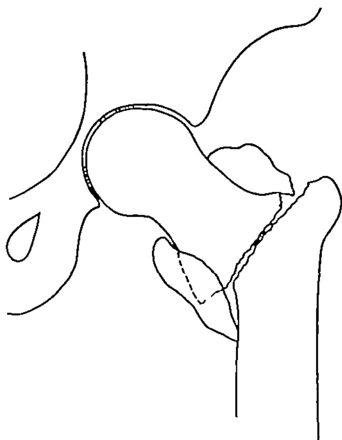


FIG 78

Prognosis.—These fractures usually heal with excellent bone repair and adequate function Occasionally a coxa vara deformity will persist with slight shortening and limitation of hip motion

Summary —

Similar in signs to intracapsular fractures

Treatment by reduction and immobilization or by traction suspension for eight weeks

Bony union the rule

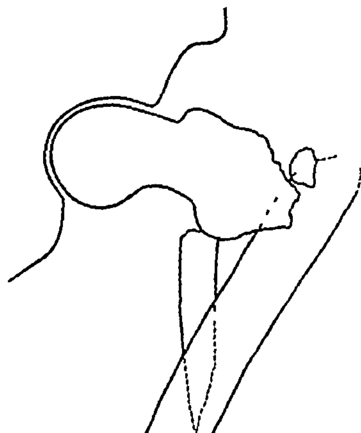


Fig 79

Subtrochanteric Fractures.—**Occurrence** —These injuries are less common than the preceding and are apt to be caused by more severe violence

Displacement.—The upper fragment is usually flexed if the lesser trochanter is still intact because of the pull of the iliopsoas. It is externally rotated and abducted by the

muscles inserted into the greater trochanter The shaft fragment is pulled up and in by the action of the strong thigh muscles (Fig 79)

Diagnosis.—The deformity is frequently marked In these cases the shortening of the extremity takes place below the trochanter (Fig 80) The relationship of Nélaton s line and

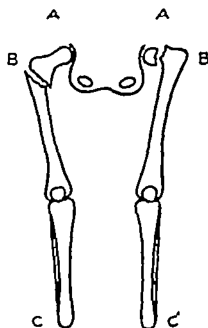


Fig 80

Bryant s triangle is unchanged That is the trochanter lies in its normal position but the measurement from the anterior superior spine to the medial malleolus is less than that of the opposite side Clinical signs of fracture are present.

Pathology—Because of the usual mechanism *i e* severe trauma these fractures are apt to be comminuted and to be accompanied by considerable soft part damage Healing

occurs with a large mass of soft callus which will allow angulation if the fracture site is not protected for a long period.

Treatment.—As a rule plaster-of Paris immobilization alone following reduction is unsatisfactory because even in a well-fitting spica there is likely to be recurrence of the deformity due to the strength of the muscle pull. Traction by means of a wire through the supracondylar region of the femur is a satisfactory form of treatment but must be maintained for from eight to ten weeks Open reduction with internal fixation has given satisfactory results in certain instances. A walking caliper brace which fits accurately against the ischial tuberosity should be maintained for at least six months after the patient is allowed to be ambulatory

Time of Immobilization.—If traction is used it should be maintained at least eight weeks with brace protection for six months

Prognosis—This is good as far as eventual union and function are concerned fair as regards anatomy

Summary—

Infrequent injuries, produced by serious accidents.
Skeletal traction usually the best form of treatment
Bony healing with mass of soft callus the usual occurrence.

Separations of the Upper Femoral Epiphysis.—**Occurrence**—This condition is usually found in young adolescents supposedly more frequently in the Fröhlich syndrome group It may be caused by a very slight trauma.

Displacement.—This is usually very similar to that found in the intracapsular fractures. The shaft is slipped upward on the head and externally rotated.

Diagnosis.—External rotation shortening pain on motions of the hip in an overweight youngster following a mild trauma should suggest a separation of the epiphysis of the femoral

head Occasionally pain down the inner aspect of the thigh to the knee due to irritation of the obturator nerve, may be the presenting symptom

Pathology —These injuries may be entirely due to trauma On the other hand in most cases trauma plays a minor rôle and the underlying factors are thought to be infectious circulatory or endocrine Only those separations which are of traumatic origin fall within the scope of this manual

Treatment.—Reduction by manipulation followed by immobilization in a plaster spica has been used with occasional success Manipulation followed by the insertion of a Smith-Petersen pin for fixation is recommended in some instances. In either case weight-bearing should not be permitted for a prolonged period of time at least a year in order to minimize the growth disturbances and changes in the head which occur late

Time of Immobilization.—At least eight weeks in plaster with prolonged freedom from weight bearing

Prognosis —The outlook for entirely free and painless hip motion is not favorable in many cases as late growth disturbances and changes in the head may result.

Summary —

- Rarely caused by trauma alone
- Underlying factors still under discussion
- Reduction followed by a plaster-of Paris spica or fixed by a Smith-Petersen nail
- Prolonged freedom from weight bearing
- Prognosis uncertain because of late changes in the femoral head

DISLOCATIONS AT THE HIP

Posterior Dislocations.—**Occurrence.**—These injuries are caused by a blow usually against the flexed knee They are somewhat rare but are said to be increasing in frequency

due to the number of automobile collisions which drive the passenger's knee against the dashboard

Displacement.—The head of the femur is pushed out of the acetabulum posteriorly and lies behind it with the femoral shaft in an acutely flexed position

Diagnosis.—The deformity presented by these injuries is characteristic. The thigh is flexed on the body and markedly adducted The femoral head can be palpated posteriorly Motions of the hip are of course markedly limited In some instances there is evidence of pressure on the sciatic nerve.

Pathology—There must be extensive tearing of the soft parts because of the force required to disrupt the integrity of the hip-joint. Occasionally part of the rim of the acetabulum is broken off The ligamentum teres is torn across to allow the femoral head to reach its new position As has been said before there may be pressure on the sciatic nerve.

Treatment.—Immediate reduction under an anesthetic is essential There are several methods described but the principles underlying them all consist in traction on the flexed thigh with rotation to slip the head back over the acetabular rim Patients may be placed on a table prone with the affected leg hanging over the edge Gentle pressure on the flexed knee with rotary motions will frequently effect a reduction Rough and jerky motions should be avoided Suspension is advisable for three or four weeks with skin traction of about 10 pounds to relax the muscle spasm followed by prolonged freedom from weight bearing Damage to the circulation of the head may result in late changes in the hip-joint, with flattening of the head and a traumatic arthritis

Time of Immobilization.—Bed rest for about four weeks followed by prolonged freedom from weight bearing i. e six months to a year

Prognosis.—This should be in most instances guarded because of danger of late changes in the hip

Summary —

Infrequent injury caused by violent trauma

Manipulative reduction followed by suspension for four weeks

No weight-bearing for at least six months

Prognosis guarded because of the possibility of late changes in the femoral head and of traumatic arthritis

Anterior Dislocations —These are more unusual than the posterior dislocations They are caused by a marked abduction force which pries the head out of the acetabulum anteriorly The deformity is the opposite to the one previously described The lower extremity is widely abducted and moderately flexed The head of the femur can be felt in the groin Traction in the axis of deformity and rotation will effect reduction The subsequent treatment is the same as that outlined for the posterior dislocations

CHAPTER XVII

FRACTURES OF THE SHAFT OF THE FEMUR.

Occurrence—These are most frequently seen in active young adults or in small children They are usually the result of a considerable trauma.

Displacement.—The original fracturing force is responsible for the initial position of the bones. Because of the great strength of the thigh muscles, shortening is almost inevitable in complete fractures that are displaced If the fracture is in the upper third of the shaft there is a tendency for the upper fragment to be flexed on the thigh because of the pull of the iliopsoas.

Diagnosis.—In most cases the diagnosis is relatively simple. Deformity and false motion make the recognition of the fracture easy *X* ray films must always be taken to ascertain the exact condition of the bone ends if they are transverse or oblique and if there is an intermediate fragment.

Pathology—Because of the intimate relationship of the vastus intermedius to the shaft of the femur for a large part of its length tearing of this muscle is an almost constant accompaniment of fracture of the femoral shaft If there is gross displacement, muscle fibers may be caught between the fragments. This interposition of soft parts is a frequent complication Nerve injuries are infrequent but vascular damage is not uncommon

Treatment.—In children under four years of age one of the simplest forms of treatment is that of suspension of both legs at right angles to the bed (Bryant's suspension) Sufficient weight applied by means of skin traction to the legs is necessary to lift the buttocks just off the mattress (Fig 81) This position is apparently perfectly comfortable for the baby and holds the fracture satisfactorily while it is healing

It should be maintained until there is evidence of adequate healing both clinically and by x-ray examination, usually in about four weeks. The baby should not be allowed to walk for a total of about eight weeks. Older children may be treated by some form of traction If skeletal traction is used, care must be taken to avoid damage to the lower epiphyseal

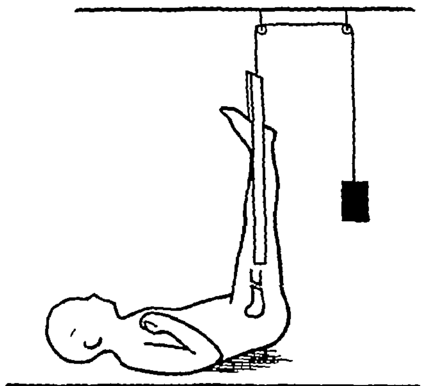


Fig 81.

line of the femur by the wire In some instances particularly of transverse fracture closed reduction followed by a plaster spica is satisfactory If the axes of the shaft are maintained a small amount of overriding in a child may be ignored there is a stimulus to growth following fracture which will correct a shortening of 2 cm within three years. Open reductions should never be done in children unless

there is interposition of the soft parts or evidence of dangerous circulatory damage

In adults the method of closed reduction and plaster immobilization is the least satisfactory It is almost impossible to maintain adequate position in a plaster spica because of the strong pull of the quadriceps and hamstring muscles. Some form of traction is essential preferably skeletal because of its efficiency, and the pull should be maintained for from

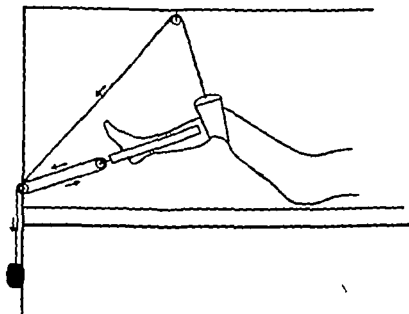


Fig. 82

eight to ten weeks. Open reduction with internal fixation which will allow active knee and ankle motion is advisable where the organization and equipment are suitable for such a procedure

A simple form of traction called the Russel or Australian method is of considerable value in treatment of these cases. Its principle is based on the double-pulley action (Fig 82)

A protective caliper brace should be worn for two or three months after the patient is allowed out of bed

Time of Immobilization.—About eight or ten weeks before weight bearing in a caliper brace is allowed

Prognosis—The prognosis should in most cases be excellent if length and axes have been restored to normal

Summary—

- A frequent injury in children and young adults
- Bryant s suspension excellent in young children
- Manipulation and plaster-of Paris immobilization in older children operation usually not necessary
- Skeletal traction or open reduction with internal fixation in adults.
- Interposition of soft parts a frequent complication
- *Immobilization* about eight weeks *followed* by a walking brace for from two to three months
- Prognosis good for union and for function if length and axes are maintained

CHAPTER XVIII

INJURIES AT THE KNEE-JOINT

FRACTURES OF THE LOWER EXTREMITY OF THE FEMUR.

Occurrence—These injuries are usually due to severe trauma and occur in active adult life. They are frequently the result of direct violence

Displacement.—This depends primarily on the direction of the fracturing force If the fracture is supracondylar the distal fragment may be pulled posteriorly by the action of the gastrocnemius muscle. If the fracture line runs between the condyles the fragments may be separated by the force of the blow (Fig 83) Fractures of a single condyle are displaced in the direction of force exerted Occasionally a small frag ment may be pulled or split from the rim of a condyle

Diagnosis.—The bony prominences around the knee may be completely obscured by swelling Pain tenderness and limitation of motion following injury will suggest the diagnosis which however must be definitely confirmed by x-ray plates.

Pathology—These injuries present a difficult problem because if the fracture involves the knee-joint, a change in the contour of the articular surface may occur thereby altering the mechanics of the joint. Soft part damage is frequently encountered. Occasionally there is injury either to the popliteal artery or to the peroneal nerve

Treatment.—These fractures must always be treated in moderate flexion to relax the pull of the gastrocnemius muscle Wire traction through the tibial tuberosity may be used for reduction in some cases This method coupled with manipu lation under anesthesia occasionally gives adequate results.

Frequently, however, the fragmentation is such that open reduction with internal fixation is the most satisfactory method These fractures are a serious problem as a residual deformity may give a permanent limitation of function Motion of the joint should be started as soon as possible to

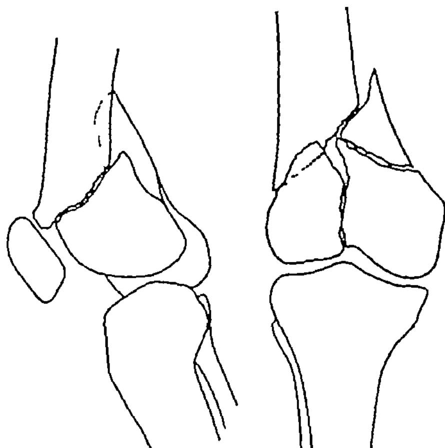


Fig 83

prevent the formation of adhesions. Traction should be maintained for from four to six weeks. Weight-bearing however should be prevented for about three months because there is danger that the soft callus of the cancellous bone will slowly collapse

Period of Immobilization.—From four to six weeks in traction about three months before weight bearing is permitted

Prognosis—This should be guarded in all cases of severe injury because of the possibility of traumatic arthritis and of limitation of motion by intra-articular adhesions. Bony union however, is the rule

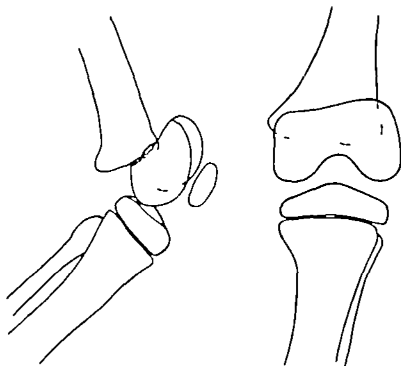


Fig 84.

Summary—

Frequently caused by direct violence.

Treated with knee flexed to relax the gastrocnemius by traction or by manipulative reduction operation occasionally necessary

Immobilization for from four to six weeks with freedom from weight bearing for three months

Prognosis good as regards union guarded as regards knee function

Separation of the Lower Femoral Epiphysis.—Occurrence—These fractures are seen in children usually between the ages of eight and fourteen years though they may occur at any age up to the time of closure of the epiphyseal line They are the result of severe accidents.

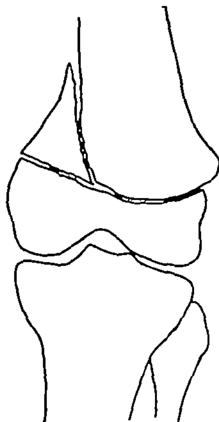


Fig 85

Displacement.—The epiphysis may be displaced forward or backward depending on the fracturing force (Fig 84) A lateral or a medial shift may also occur and rotation of the distal fragment is occasionally seen Frequently the epiphysis takes with it a wedge-shaped fragment of the diaphysis (Fig 85)

Diagnosis.—Symptoms and signs of fracture at the lower extremity of a femur of a child should strongly suggest the diagnosis *X*-ray examination is essential

Pathology—Because of the severity of the injury there is usually considerable soft part damage Occasionally the displacement is so marked that the popliteal vessels and nerves are injured

Treatment.—Reduction under anesthesia can usually be accomplished if the knee is held in flexion to relax the gastrocnemius muscle, while by traction and manipulation the epiphysis is slipped into place Immobilization should be carried out by molded plaster splints or circular casing with the leg acutely flexed on the thigh The splints should be maintained for six weeks after which the patient may be allowed to begin weight-bearing

Time of Immobilization.—Usually six weeks

Prognosis.—There is normally complete return of function in about six months Growth disturbances are not infrequent however and may take place on one side of the epiphyseal cartilage only resulting in marked deformity

Summary—

Injury caused by severe trauma.

Deformity frequently marked

Treatment manipulative reduction with knee flexed followed by immobilization in flexion for six weeks.

Prognosis guarded because of danger of growth disturbance.

FRACTURES OF THE PATELLA.

Occurrence.—These are of fairly frequent occurrence and may be caused either by direct or by indirect violence.

Displacement.—If the blow is direct the fracture is apt to be stellate or fragmented and not displaced (Fig 80) If however, indirect violence, either alone or coupled with direct violence, is the causative factor there is usually tearing of

the aponeurotic expansion of the quadriceps (Fig 87) Contraction of that muscle pulls the proximal fragment upward frequently for a distance of some centimeters

Diagnosis.—Because of the superficial position of the patella the deformity is easily

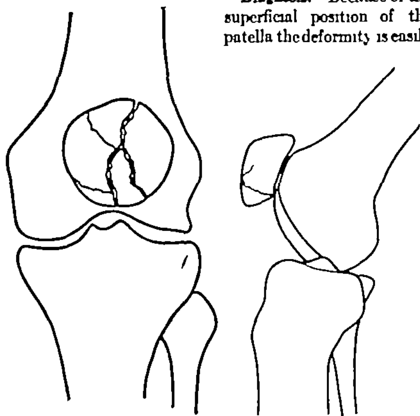


Fig. 86.

palpated in most instances. Occasionally the soft part damage is so great that the bony outline cannot be felt *X*-ray films taken not only in the antero-posterior and lateral planes but also in obscure cases from above downward through the flexed knee will give the diagnosis.

Pathology—The most important consideration in these injuries is the integrity of the soft parts The patella is actually a sesamoid bone in the quadriceps tendon and may be crushed by a direct blow without tearing the surrounding

Diagnosis.—Symptoms and signs of fracture at the lower extremity of a femur of a child should strongly suggest the diagnosis. X ray examination is essential

Pathology—Because of the severity of the injury there is usually considerable soft part damage Occasionally the displacement is so marked that the popliteal vessels and nerves are injured

Treatment.—Reduction under anesthesia can usually be accomplished if the knee is held in flexion to relax the gastrocnemius muscle while by traction and manipulation the epiphysis is slipped into place Immobilization should be carried out by molded plaster splints or circular casing with the leg acutely flexed on the thigh The splints should be maintained for six weeks after which the patient may be allowed to begin weight bearing

Time of Immobilization.—Usually six weeks.

Prognosis.—There is normally complete return of function in about six months. Growth disturbances are not infrequent however and may take place on one side of the epiphyseal cartilage only resulting in marked deformity

Summary—

- Injury caused by severe trauma
- Deformity frequently marked.
- Treatment, manipulative reduction with knee flexed followed by immobilization in flexion for six weeks.
- Prognosis guarded because of danger of growth disturbance.

FRACTURES OF THE PATELLA

Occurrence.—These are of fairly frequent occurrence and may be caused either by direct or by indirect violence.

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week, but unprotected weight bearing should not be allowed for from four to six weeks If for some reason operation is impossible the separate fragments may be pulled together to some extent by strips of adhesive on the skin and the extremity then immobilized in extension in circular plaster for from four to six weeks. This is however, a very poor second best

Time of Immobilization.—Two or three weeks in fractures without separation Protection for four weeks after operation but early guarded motion

Prognosis—If the articular surface heals smoothly the patient should have a satisfactorily functioning knee Irregularities on the articular surface may cause pain on certain motions. As a rule the prognosis is good

Summary—

- Caused by direct or indirect violence
- Undisplaced fractures treatment by posterior molded splint for two weeks followed by active motion
- Displaced fracture treatment by open reduction internal fixation and repair of aponeurosis guarded weight-bearing in four weeks.
- Prognosis usually good

FRACTURES OF THE UPPER EXTREMITY OF THE TIBIA.

Occurrence—These injuries are increasing with the frequency of automobile accidents Many of them are caused by a blow from a car bumper

Displacement—The fracture line may be completely across the upper end of the tibia, it may be T- or Y-shaped or it may involve one condyle only The most frequent site of injury is the lateral condyle, the cause a blow on the outer aspect of the knee-joint with forceful abduction of the leg on the thigh (Fig 88) The condyle is frequently displaced downward sometimes in one piece sometimes crushed in many pieces. If the blow is on the medial aspect of the knee

soft tissue If such be the case the problem is much simplified On the other hand if the aponeurosis is torn opening the joint and separating the bony fragments the situation is more complicated

Treatment.—Where there has been no separation of the fragments, a posterior molded splint for a couple of weeks

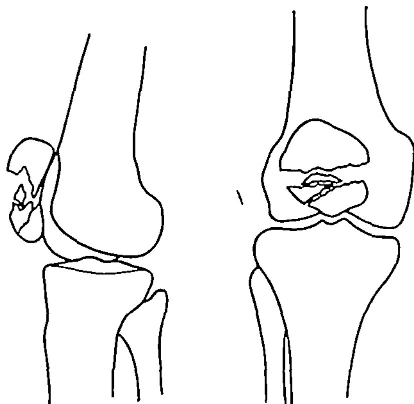


Fig. 87

followed by guarded active motion is all that is necessary *If there is separation of the fragments the best form of treatment is that of open reduction and fixation of the fragments by some means* fascia, wire, silk, etc. coupled with a careful repair of the aponeurosis and capsule. If the repair is sufficiently firm guarded active motion may be begun within a

ment only may result from such an injury in which case with a blow on the outer side of the knee all the signs and symptoms will be referred to the medial side X ray pictures are essential for the diagnosis.

Pathology—As always with a fracture into a joint, one of the presenting symptoms is that of blood in the joint accumulating gradually in the first hours after the accident. Tearing of the collateral ligament as has been mentioned is a frequent complication The semilunar cartilages may also be torn or detached at the time of injury Because of the character of the bone involved in the fracture the deformity may gradually increase if too early weight-bearing is allowed the cancellous bone may crush down if the weight of the body is applied before the healing process is firm If there is also a fracture of the fibular neck damage to the peroneal nerve may occur either at the time of injury or later from pressure by the callus.

Treatment.—In cases where the displacement is negligible, aspiration of the joint followed by elevation and immobilization for two or three days is the initial treatment. Active motion without weight-bearing should be begun as soon as the swelling and tenderness have subsided This can be most easily accomplished in a suspension apparatus with a hinged footpiece and skin traction on the lower leg of 2 or 3 pounds weight to pull the joint surfaces apart. This should be continued for two or three weeks after which the patient should be allowed up and permitted to walk with crutches without bearing weight on the affected leg If the portion of the condyle involved in the fracture is small weight bearing may be begun somewhat sooner If it involves a considerable portion of the articular surface however even with no initial displacement of the fragment weight-bearing should not be permitted until after twelve weeks from the time of injury In cases where there is gross displacement closed reduction may be attempted but is frequently very difficult Malleting the fragment into place or compressing the condyles with a giant form of nut-crackers

forced adduction may cause a depression of the medial condyle

Diagnosis.—There may be definite change in the axis of the leg on the thigh depending on the amount of depression of the condyle. There is frequently considerable swelling with a marked hemarthrosis if the capsule of the joint remains intact. Instability of the knee-joint with increase in ab- or

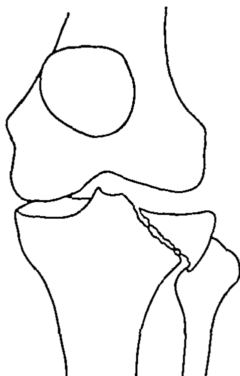


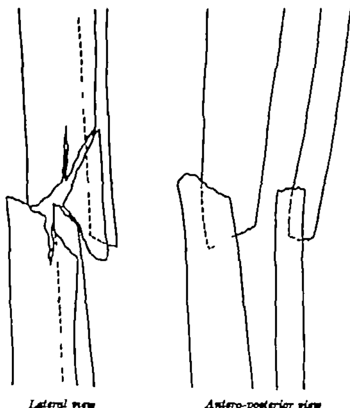
FIG. 88.

adduction depending on the site of injury is evidence of a torn collateral ligament. If there is acute tenderness on the side opposite to that of the torn ligament, that is if in a patient whose leg can be abnormally abducted on the thigh there is tenderness over the lateral tibial condyle it is indicative of a fracture of the condyle as well as a tear of the medial collateral ligament. Occasionally a tear of the liga

CHAPTER XIX

FRACTURES OF THE SHAFTS OF THE TIBIA AND FIBULA

Occurrence —These fractures are due either to direct or indirect violence Children and young active adults are most likely to incur these injuries



Lateral view *Antero-posterior view*

FIG. 80

Displacement.—If the blow is direct the fracture is frequently transverse and there may be a triangular fragment split from it on the side opposite to that which received the blow (Fig 89) If direct both bones are likely to be broken at the same level If the violence is indirect the fracture is

may replace the fragments A circular plaster should then be applied to hold the position obtained Immobilization should be continued for from six to eight weeks followed by active motion without weight-bearing for another four weeks. Occasionally the displacement may be corrected by traction, either skin or skeletal in either abduction or adduction depending on the deformity with swathes on the apparatus to maintain side pull If the fragments are not too small open reduction with fixation by nails or bolts presents the best form of treatment, as it allows early active motion if rigid fixation of the fragments has been accomplished

Period of Immobilization.—Six to eight weeks following closed reduction No weight-bearing for twelve weeks

Prognosis.—If there has been little deformity so that active motion can be maintained almost from the beginning the prognosis should be good If immobilization is necessary there may be limitation of the full range of motion Residual deformity may result in pain and limitation of function

Summary —

Frequent injury from automobile bumpers
Lateral condyle usually depressed and may be associated with tearing of medial collateral ligament.
If undisplaced aspiration and early active motion without weight-bearing
If displaced reduction by malleting or compression followed by immobilization in plaster-of Paris or open reduction with internal fixation
No weight bearing for twelve weeks unless insignificant portion of articular surface involved
Prognosis for function guarded

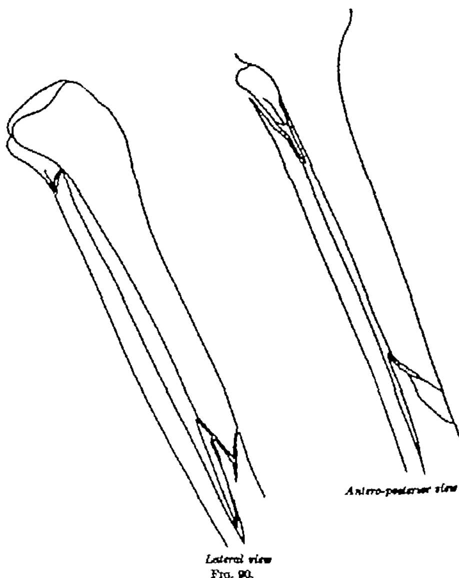
Fractures of the Tibial Spine —These injuries may occur from indirect violence and are frequently due to the pull of the crucial ligaments If there is little or no displacement immobilization of the knee in extension for three or four weeks is all that is necessary If there is great displacement open *reduction must be done with fixation of the fragment,* or if that is not possible with its removal

especially in the injuries of young children where the fracture may be subperiosteal a line of bony tenderness and the presence of indirect tenderness should suggest the diagnosis X ray films in two planes are important.

Pathology —These are injuries of violence and in most cases there is apt to be extensive soft part damage with considerable bleeding within the tissues The skin may be avulsed or lifted up from the underlying soft parts by hemorrhage, as in cases where a wheel passes over the leg Compound fractures are frequently seen Circulatory embarrassment due to the tense swelling of the calf may occur Volkmann's paralysis of the lower extremity has been reported though less frequently than in the upper extremity Delayed or non-union is a not infrequent result of fractures of the tibial shaft.

Treatment.—Manipulation or closed reduction under an anesthetic followed by immobilization in plaster is an adequate method of treatment for the fractures of children where the displacement can be easily corrected and in adults where the fracture is transverse or involves one bone only Posterior molded and sugar tongs splints extending well above the knee make a satisfactory apparatus because it permits observation of the skin and avoids the danger of constricting plaster After the swelling has gone down a circular plaster casing may be applied from toes to groin It should be remembered that if the knee be flexed it will tend to prevent the slipping of the leg in the casing This method of treatment is not advisable, however for adults with oblique fractures because it does not prevent the shortening of the bones. A satisfactory method is that of the insertion of two wires (one above and one below the fracture site) the reduction of the fracture and then the encasing of the wires and the extremity in plaster so that the position of the fragments is maintained In such cases the plaster need come only to the knee and the patient can be allowed up and around in a few days after the danger of swelling has passed In both forms of treatment the immobilizing apparatus

spiral with the fibular break usually higher than that of the tibia (Fig 90) Overriding is due to the pull of the muscles. The initial displacement is caused by the fracturing force.



Antero-posterior view

Lateral view
FIG. 90.

Diagnosis —In cases where there is any displacement the diagnosis is evident. Deformity crepitus, false point of motion all are present. Where there is no displacement,

CHAPTER XX

INJURIES AT THE ANKLE-JOINT

FRACTURES OF THE MALLEOLI.

Fractures of the Lateral Malleolus.—Occurrence.—These injuries are very common and may be due to either direct or indirect violence. They usually occur in young adults.

Displacement.—If the injury is due to the sudden inversion of the foot the lateral malleolus may be pulled off by the external collateral ligament. However, the ligament is more likely to tear causing a sprain rather than a fracture. If the fracture is due to an outward rotation of the foot with pressure against the lateral malleolus the fracture line is usually spiral or oblique and the fragment may be displaced outward. Marked displacement is unusual without a tearing of other structures.

Diagnosis.—It is extremely difficult to differentiate between a sprain of the ankle and a fracture of the lateral malleolus. Tenderness along the lower extremity of the fibula is suggestive of the latter but may be present in the former if the ligamentous attachments have been pulled from the bone. *X*-ray examination is essential in all injuries of the ankle where fracture is even remotely suspected.

Pathology.—There may be considerable ligamentous tearing with resultant swelling and ecchymosis. There are usually no injuries to nerves or large blood vessels.

Treatment.—Where there is no displacement the leg should be immobilized in some form of splint for a few days with elevation and heat in order to reduce the swelling. Adhesive strapping may be substituted for the splint as soon as the soft part pathology subsides. Weight-bearing with the ankle protected by strapping or ankle brace may be allowed in ten

should be maintained for about eight weeks. When it is impossible to obtain satisfactory position i. e normal length and correct weight bearing axis, or to maintain it by either method open reduction becomes an operation of necessity Because of the possibility of early return of function of the knee and ankle open reduction with internal fixation has proved satisfactory in those institutions where the organization for such a procedure is adequate Under such circumstances the operation is one of choice These cases may be allowed up in a brace in about four weeks Fractures at the junction of the middle and lower thirds of the tibia are apt to be slow in healing and may proceed to a fibrous union Multiple drilling massive bone grafts, bone chips are all methods suggested for the treatment of non-union

Time of Immobilization.—If plaster-of Paris or traction is used it should be maintained for from eight to ten weeks and a brace may be necessary thereafter if union is delayed.

Prognosis.—This should be good in children and in many adults It should be definitely guarded however, in fractures of the tibia at the middle and lower third where delayed union may result.

Summary —

Severe direct or indirect violence the usual cause
Reduction and immobilization in plaster satisfactory for fractures in children and in undisplaced fractures of adults
Wires above and below the fracture and incorporated in the plaster casing valuable in oblique fractures.
Open reduction occasionally necessary
Delayed and non union a danger
Prognosis guarded.

Fractures of the Shaft of the Fibula.—These injuries are usually due to direct violence a blow against the outer side of the leg The displacement is negligible if the tibia is intact and the treatment is merely that of protection against *further* injury A lateral splint and the use of crutches for a week or so are all that is required

motion of the talus is normally impossible because of the 'mortise' shape of the joint holding the talus firmly between the malleoli (Fig 92) Supination, pronation ab- and adduction of the foot take place in the subtalar and midtarsal joints. The malleoli are subcutaneous and easily palpable The tip of the lateral malleolus lies distal and

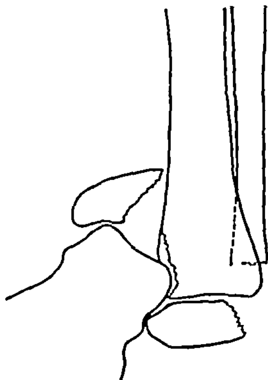


FIG. 91

slightly posterior to the medial A line dropped from the anterior-superior spine through the patella should pass through the center of the talus It is important for the function of the joint that the mortise be restored and the weight-bearing axis maintained

Because the deformity in these cases is likely to be great the diagnosis may be evident at a glance If there is no

days or two weeks In cases where there has been displacement requiring reduction, posterior molded and sugar tongs splints should be applied which extend from toes to knee. These should be maintained for about two weeks and followed by strapping and an ankle brace

Time of Immobilization.—A few days to two weeks, depending on the amount of soft part damage and the original displacement.

Prognosis.—This should be good both as regards function and anatomy

Summary —

- Frequently difficult to differentiate from a sprain
- Treatment—reduction if necessary, immobilization and elevation
- Soft part damage important consideration
- Weight-bearing with protective strapping in about two weeks.
- Prognosis good

Fractures of Both Malleoli.—**Occurrence** —These injuries are caused by considerable violence frequently by a fall on a twisted foot. They occur usually in people engaged in strenuous activities.

Displacement.—The foot with the malleoli may be displaced either outward or inward depending upon the direction of the fracturing force Displacement in these cases may be very marked (Fig 91) Because of the pull of the calf muscles there is almost always a backward displacement as well There may or may not be a fracture of the posterior lip of the tibia.

Diagnosis.—The ankle is a hinged joint formed on the one side by the lateral malleolus the inferior tibio-fibular ligament, the articular surface of the tibia and the medial malleolus, and on the other by the talus. The upper surface of the talus is curved convexly from before backward which allows it to rock on the tibial surface and permits flexion and extension of the foot on the leg Lateral medial or rotary

weeks. The patient may be allowed up on crutches without bearing weight on the injured extremity as soon as the swelling has subsided Hot soaks and active motion of the ankle may be started in four or five weeks and weight bearing on the strapped ankle in from six to eight weeks Frequently following these injuries the patient complains of pain in the foot from a traumatic flat foot This can be to a large measure prevented by having lifts placed on the inner side of the sole and heel of the shoe before weight bearing is allowed

Time of Immobilization.—Some form of splint protection should be maintained for from four to six weeks

Prognosis.—In spite of gross initial deformity these patients usually get very satisfactory ankle-joints Swelling at the end of the day may persist for months

Summary —

Severe violence usually causative factor

Deformity usually marked with displacement of foot either inward or outward and backward

Treatment—reduction followed by immobilization in splints for from four to six weeks

Prognosis usually good

Fractures of the Lower Third of the Fibular Shaft and the Medial Malleolus Associated With Separation of the Inferior Tibio-fibular Ligament (Pott's) —These fractures are of considerable importance although they are not common They are caused by a violent twist of the foot outward frequently with rotation The result of this force is to pull off the medial malleolus and pry the fibula outward rupturing the inferior tibio-fibular ligament and breaking the fibula through the lower part of the shaft (Fig 93) The foot is displaced outward backward and upward and the deformity may be marked Early reduction is not difficult if the leg is kept flexed on the thigh in order to relax the gastrocnemius muscle Traction downward overcomes the shortening Pressure forward on the calcaneus corrects the backward displacement and the foot may then be placed in correct

displacement tenderness over both malleoli with pain and swelling accompanied by lateral instability of the ankle-joint, suggests the diagnosis X ray films are necessary to show the detail of the fractures.

Pathology —These are primarily bone injuries and are apt to occur without great ligamentous damage There is usually considerable tearing of the soft parts however with resultant swelling which may be extensive Nerve and large vessel injuries are rare

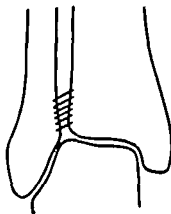


FIG. 92.

Treatment.—If these cases are seen early reduction is usually surprisingly easy If the knee is held in flexion to relax the gastrocnemius muscle steady traction on the heel and foot will frequently allow the bones to slip back into place The malleoli can be molded into position by direct pressure Following reduction the ankle should be immobilized in posterior molded and sugar tongs splints carried above the knee to maintain the position of flexion The foot should be held at about right angles to the leg and in mid-position with possibly a slight inversion Too marked inversion will force the talus against the fibular fragment displacing it outward Elevation immediately following reduction is important because of the danger of swelling The splints may be cut below the knee in from two and a half to three

treatment needed in these cases open reduction has been advocated, with replacement of the fragments and fixation of the fibula to the tibia by screws or a bolt. This allows the patient to be up and back at work weeks before he would be able to walk if treated by the other method

Separation of the Epiphysis —Separation of the epiphysis of either tibia or fibula may occur with or without displacement. Reduction is necessary if displacement exists, and immobilization with posterior molded and sugar tongs splints is the advised treatment with no weight bearing for from three to six weeks. In most instances the prognosis is good but the danger of growth disturbances should always be remembered

FRACTURES OF THE LOWER EXTREMITY OF THE TIBIA.

Complicated Fracture of the Lower Extremity of the Tibia. —Occasionally a comminuted fracture of the tibia with multiple fracture lines into the joint may be caused by a fall from a height. This type of injury is frequently very difficult to reduce A wire through the calcaneus and one through the tibial shaft may be used to pull the fragments into position The wires may be incorporated in a plaster boot and the patient allowed up after the danger of further swelling has passed Frequently however traction will not influence some of the fragments and open reduction is indicated The prognosis should be guarded because of the possibility of the development of traumatic arthritis and pain on weight-bearing

DISLOCATIONS AT THE ANKLE-JOINT

Pure dislocations are extremely rare They are almost invariably associated with a fracture or with a rupture of the inferior tibio-fibular ligament. Reduction by manipulation followed by immobilization as previously described, is the method of treatment.

line with the tibia and held there by firm pressure on the malleoli to compress the widened mortise

Following reduction posterior molded and sugar tongs splints from the toes to above the knee should be applied while the foot is held in position and the malleoli pressed tightly together The foot should be held at right angles to the leg and in a very slight inversion Marked inversion tends to displace the fibular fragment. This position should be maintained for about four weeks before the splints are loosened or cut down below the knee. At about six weeks

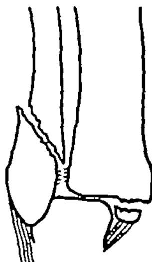


FIG. 93.

hot soaks and active motion may be started, but weight bearing should not be complete until twelve weeks after injury because of the tear of the inferior tibio-fibular ligament. If patients with this injury are permitted to walk too soon a widened mortise and an unstable joint may result. Lifts on the inner side of the shoes when weight-bearing is allowed will tend to prevent traumatic flat-foot and elastic *bandages will prevent excessive swelling of the lower extremity* Return to function is usually complete between six and eight months. Moderate edema of the ankle may last considerably longer than that. Because of the long period of

of the talus across the neck with displacement of the anterior portion (Fig 91) or the crushing injuries of the body may be very difficult to diagnose and to treat Correct diagnosis is made by x-ray examination In certain instances a closed reduction may be possible, but in others operative replacement is essential Removal of the fragments may be necessary Immobilization for from four to six weeks with no weight bearing for a total of eight weeks is the usual procedure

Fractures of the Calcaneus —**Occurrence** —These are the most frequent fractures of the tarsus and are usually caused by *a fall from a height the patient landing on the heels*

Displacement.—The supero-posterior angle of the bone may be pulled off by the Achilles tendon On the other hand there may be a complete fracture through the body of the bone or a crushing injury resulting in a widening of the transverse diameter and a flattening of the superior surface

Diagnosis —A swollen tender broadened heel following a drop from a height is suggestive of a fracture of the calcaneus Frequently the swelling is so great that the outlines of the bone cannot be palpated *X* ray pictures should be taken not only in the antero-posterior and the lateral planes but also from above downward and forward

Pathology —Of great importance is the superior articular surface of the calcaneus because an irregularity persisting here may give the patient traumatic arthritis of the subtalar joint and a painful foot. Frequently the fracture is comminuted

Treatment.—If the Achilles tendon is pulled off with a fragment of bone operative reduction with internal fixation is usually the best procedure If the fracture is a crushing injury with disturbance of the articular surface or if there is an upward tilt of the posterior fragment, the deformity is frequently best overcome by the distraction pull of two wires one through the posterior fragment of the calcaneus and one

CHAPTER XXI

INJURIES TO THE FOOT

FRACTURES OF THE TARSUS

Fractures of the Talus.—These injuries may occur at any age but are usually found in active adults. They may be insignificant an avulsion fracture caused by the pull of a

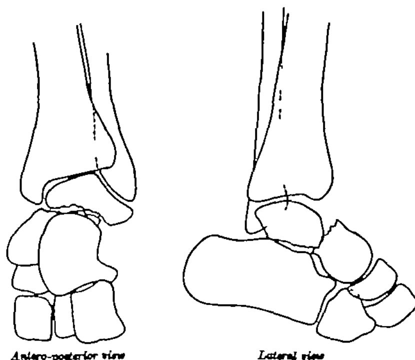


FIG 94.—Fracture of the talus.

ligament, or they may be serious, a break through the body of the bone caused by severe violence. The former should be considered as sprains, not fractures, and the attention centered on the soft part pathology. The complete fractures

Summary —

Causative factor a fall from a height

Crushing injury with widening of the bone and upward angulation of the posterior portion

Reduction by wire pull and manipulation

Plaster boot immobilization for eight weeks

Prognosis guarded

Other Fractures of the Tarsus —These are of infrequent occurrence and relatively little importance Soft part damage should receive the first consideration

FRACTURES OF THE METATARSALS

These injuries may be caused by direct or indirect violence The displacement is usually due to the direction of the fracturing force They are characterized by massive swelling Elevation and heat should be employed at once to reduce the swelling Frequently the displacement can be corrected under an anesthetic but occasionally traction preferably skeletal through the phalanges is necessary A circular plaster boot should be maintained for from four to six weeks Particular care should be taken to regain the curve of the metatarsals Lateral displacement will not cause permanent difficulty but plantar angulation or a bony prominence on the weight-bearing surface will cause later difficulty in walking

Fractures at the Base of the Fifth Metatarsal.—These fractures occur usually when the foot is sharply inverted with the body weight forward on the front part of the foot as in running A sudden strain is placed on the peroneus brevis muscle at its insertion in the base of the fifth metatarsal These injuries are frequently overlooked and diagnosed as sprains They are characterized by tenderness directly over the base of the fifth metatarsal which is prominent and easily palpated The treatment consists either of a plaster boot or of an adhesive plaster strapping with a felt doughnut over the fracture site If the strapping is adequate

through the tibia (Fig 95) *Considerable force is needed* to overcome the pull of the calf muscles and to replace the fragments. The broadening of the heel due to the crushing of the bone can be corrected either by direct manual pressure or better by a well padded vise or compression clamp After the swelling has gone down the wires can be incorporated in a plaster boot. Weight bearing should not be

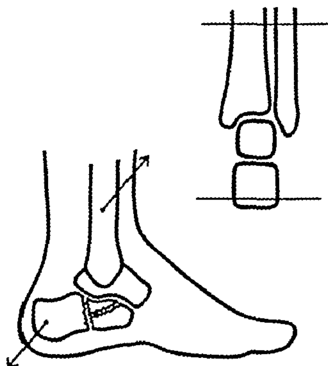


FIG 95.

allowed for eight weeks and then in a specially built shoe with a prolonged counter and a sponge in the heel

Time of Immobilization.—The plaster boot should be maintained for approximately eight weeks

Prognosis—This should be guarded as these fractures frequently result in discomfort on walking and standing and a permanent disability

to prevent a pull on the peroneus brevis the patient is usually able to walk in more or less comfort by the end of the second week. Occasionally these fractures do not heal by bony union but in most instances the fibrous union is adequate for function

FRACTURES OF THE PHALANGES

These are frequently crushing injuries caused by a weight falling on the foot, stubbing the toes against furniture in the dark is another method of injury The fractures may be accompanied by considerable swelling of the soft parts If the breaks are in the shafts of the four small toes adhesive strapping around the affected toe and the one next it to act as a splint may be all that is necessary If more than one toe is injured a plaster sole for immobilization for a few days is satisfactory Occasionally a reduction is necessary if the deformity is such that it will interfere in weight-bearing Restoration of full mobility of the joint is not of great importance Three or four weeks is usually all that is necessary for protection but tenderness may persist for some time thereafter

DISLOCATIONS AT THE METATARSO-TARSAL JOINTS

Rarely cases are seen where the entire row of metatarsals is displaced on the tarsus The deformity is marked In early dislocations reduction under an anesthetic is relatively simple Immobilization with no weight-bearing for two or three weeks should be all that is necessary Dislocations of the toes are not common but occasionally occur and are usually easily reduced

INDEX

NOTE —Words such as anesthesia fractures, immobilization reduction and many others which occur throughout the book are indexed only where their general significance is discussed

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